Aquaponics in Puerto Rico

Assessing Opportunity in the Growing Industry

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Submitted by:

Timothy Granger
Katherine Newell
Kyla Wesley
Paige Westlake

Submitted to:

Agroponicos Cosecha de Puerto Rico, Inc.
Fabienne Miller, Project Advisor, Worcester Polytechnic Institute
Edward A. Clancy, Project Advisor, Worcester Polytechnic Institute

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Abstract

Agroponicos Cosecha de Puerto Rico, Inc. operates the only aquaponics farm in Puerto Rico. Their goal is to create a widespread aquaponics industry on the island. We evaluated the opportunities for this industry's growth by surveying the market interest of consumers, restaurants and grocery stores, and evaluating education in the field of aquaponics. The market was assessed based on organic and GMO-free products and education was evaluated based on a one-day vocational workshop about aquaponics. Data were analyzed, which indicated a lack of knowledge of organic and GMO-free products in the community. We created multiple recommendations for Agroponicos including distribution of informational pamphlets and the use of evaluation surveys for aquaponics workshop improvement.

Executive Summary

The decline of the agriculture industry in Puerto Rico over the past several decades has greatly affected the territory's economy and food supply (Department of Latin American and Puerto Rican Studies, 2002). Some of the major economic problems associated with this decline include a small labor force in the agriculture industry, a relatively high unemployment rate, a small percentage of arable land, and a high food import rate (Central Intelligence Agency, 2013). There is a possibility to remedy this economic situation by expanding the agriculture industry in Puerto Rico, specifically through non-traditional farming methods.

Aquaponics is an alternative farming technique and a potential solution for the expansion of the agriculture industry in Puerto Rico. This technology combines aquaculture and hydroponics, and does not require arable land because produce is grown in waterbeds rather than soil. Food products grown in these systems include fish, vegetables, fruits and herbs and are usually organic and free of genetically modified organisms (GMO-free) (Diver, 2006). Agroponicos Cosecha de Puerto Rico, Inc. is currently using this farming technology on the island and plans to expand the agriculture industry in Puerto Rico through aquaponics. They believe that aquaponic technology holds the potential for new business opportunities, employment and local sources of high quality food products. Agroponicos hopes to achieve this goal by focusing equally on increasing production and community education on this technology. The company expects to expand their production and as a result, the demand must increase simultaneously with the supply. The successful sale of products grown through aquaponic systems is largely dependent on consumers' knowledge of and willingness to purchase organic and GMO-free options in combination with restaurants' and grocery stores' knowledge of and willingness to provide these products. Aquaponics education is also vital to the expansion of the technology and the agriculture industry because vocational workshops increase interest and provide the skills needed to run an aquaponic system. To evaluate the growth potential for aquaponic technology on the island, our team researched two main project objectives:

1. Assessment of the market for local, organic and GMO-free food products to represent the market interest in aquaponic products.
2. Evaluation of aquaponics education, specifically a one-day vocational workshop.

For the first objective, we distributed three different surveys to general consumers, restaurant managers and chefs, and grocery store managers, respectively. Using the data collected from these surveys, we aimed to answer the following questions:

- What is the community's knowledge of organic and GMO-free foods?
- What is the market's willingness to buy organic and GMO-free foods?
- Where is the strongest market interest in products grown in aquaponic systems (organic and GMO-free)?
- Are restaurants interested in a small-scale aquaponic system for their business?

Results from all three surveys were compiled and compared to address each of these questions. Many of our statistical analyses were drawn from our general consumer survey, which had the highest number of responses at 106. Consumers' basic understanding and purchasing of organic and GMO-free products are shown in Figure 1.

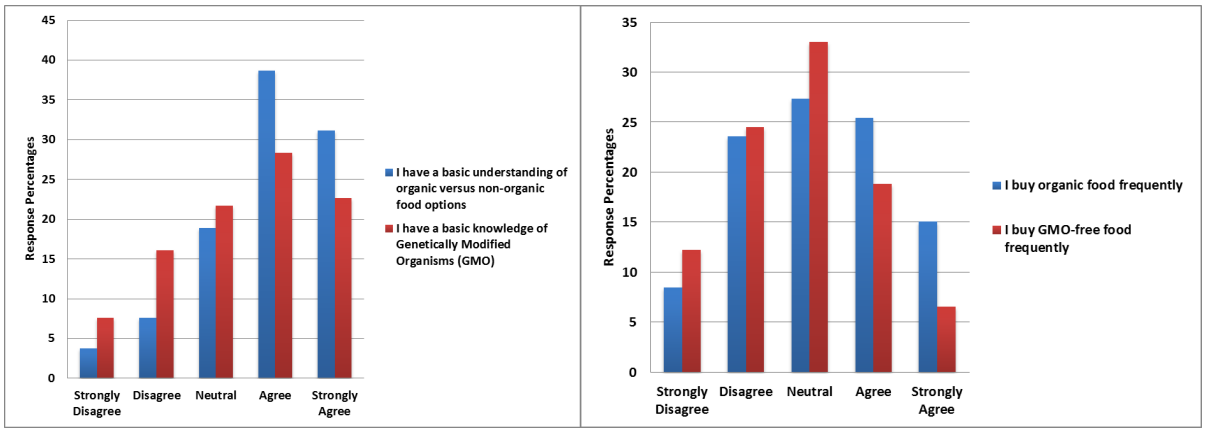

Figure 1: Consumer Survey- Basic knowledge and purchasing patterns of organic and GMO-free food products

The Pearson correlation between knowledge of organics and knowledge of GMO-free was 0.450 ($p<0.001$). This significant positive correlation shows that more knowledge in organic foods is associated with more knowledge of GMO-free foods. Surveyed consumers residing outside of Puerto Rico indicated that they have more knowledge of organic products than those in Puerto Rico ($t=-2.694$, $p=0.008$). We also compared buying patterns between organic and GMO-free products. The majority of consumers who buy GMO-free also buy organic, but those who buy organic do not necessarily buy GMO-free. Results show a significant correlation ($p=0.003$) between consumer purchasing of organic products and purchasing of GMO-free products with a Pearson correlation value of 0.293.

One important result found in the survey data was a significant correlation ($p<0.001$) between consumer's self-rated knowledge and purchasing patterns of organic and GMO-free food products with a Person correlation 0.399, indicating those who know about organic foods are more likely to purchase organic foods. The Pearson correlation between knowledge of GMO-free foods versus purchasing GMO-free foods is very similar at 0.412 ($p <0.001$), meaning that generally those who are familiar with GMOs are more likely to purchase GMO-free foods. These results led us to believe the community's willingness to buy products grown through aquaponics is somewhat dependent on the community's level of education about organic and GMO-free options.

Statistical tests found no significant differences in purchasing patterns in restaurants based on type ("fast casual", "casual" and "fine dining") or location (Old San Juan, Condado and Isla Verde). Three ANOVA tests using organic, domestically grown and GMO-free products

used by restaurants did not differ significantly with restaurant type (F=0.992, p=0.379; F=0.848, p=0.435; and F=0.053, p=0.949; respectively). Three ANOVA tests were performed to compare restaurant locations. These tests show that organic, domestically grown and GMO-free products used by restaurants are not dependent on restaurant location (F= 0.584, p= 0.449; F= 2.579, p= 0.088; and F= 0.147, p= 0.704; respectively). No conclusive statistics could be used to evaluate which type of grocery store or store location was the best market for organic and GMO-free products due to the small sample size of eleven.

Also, restaurants were asked if they would be interested in having a fully serviced small-scale aquaponic system in their restaurant. Over half of the restaurants surveyed, 51%, indicated they might be interested in an aquaponic system. We believe there is potential for growing the aquaponics industry in restaurants through this strategy, but those restaurants who were "unsure" about having a system would benefit from further information about cost, size, and maintenance.

Our team then investigated the second project objective by assessing the current education in aquaponics, specifically a one-day workshop at Caribe Fisheries in Lajas, Puerto Rico co-taught by the farm owner and Agroponicos' Pedro Casas Jr. We used the literature review, interviews with a representative from WPI's Corporate and Professional Education and a researcher working with the Aquaponics Institute to develop a plan to evaluate the one-day vocational workshop. An interview with the aquaponics instructor was conducted to establish goals and learning objectives. Evaluation surveys were then created and distributed to ten attendees at the vocational workshop directly following the program. Using the data obtained through these interviews and survey, we addressed the following questions:

- Who is the audience? Why are they taking the workshop?
- Are the instructor's goals lining up with the attendees' goals?
- Are the instructors stimulating interest in their workshop attendees? Are their teaching styles effective?
- How do the workshops create potential opportunities to grow the aquaponics industry?

The survey data collected reflected overall high ratings of the program's organization, material covered, and instructors' teaching styles. Based on the surveys completed by the attendees of the Lajas workshop, four participants agreed and six participants strongly agreed the program met most of their expectations, indicating a 100% satisfaction rate. The majority of workshop participants rated the program "perfect" on a five-point Likert scale on multiple questions; nine believed the amount of material presented was perfect, six for intellectual challenge, nine for amount of time spent lecturing, and seven for time spent with hands-on learning. We also assessed the workshop attendees' satisfaction with the two instructors' teaching. On a five-point Likert scale from "very poor" to "very good," nine participants rated the aquaponics instructor's teaching "very good" and one rated "good." All attendees plan to use their newly obtained knowledge to build or maintain a personal and/or commercial aquaponic system, and all attendees would recommend the program to others. The extremely positive

feedback and small sample size made determining areas for improvement difficult, but our team provided Agroponicos with self-evaluation surveys for feedback on future workshops and to distribute to participants that have attended aquaponics workshops in the past.

Our team created recommendations for Agroponicos based on the analyzed results to improve their marketing approach and instructional programs for the expansion of the aquaponics industry in Puerto Rico.

For market interest:

- Emphasize organic and GMO-free on product labels and advertisements
- Educate consumers and restaurant owners about the benefits of organic and GMO-free products
- Can also place an emphasis on marketing the products as locally grown
- Present business models to restaurants for growing their own produce through aquaponic systems

By focusing on educating the community about the benefits of organic and GMO-free produce Agroponicos can potentially increase sales because results show there is a significant positive correlation between knowledge of organic and/or GMO-free products and buying them. Data show that 76% of consumers know about health benefits associated with these foods but not about other potential benefits including taste and shelf life of the products. Education via informational pamphlets at schools, promotional events, restaurants, and grocery stores can help increase the market interest in aquaponics products. A company website would be a useful tool to aid in the education of the community by including information about organic and GMO-free food products created in aquaponic systems and the benefits of consuming these products. There is also a need to create a business plan for the small-scale models for restaurants with size, price, and maintenance details because 51% of restaurants indicated they might be interested in a system but would need more information to make this decision.

For aquaponics education:

- Utilize Agroponicos Facebook page for marketing
- Improve workshop experiences by tailoring to the audience and improve workshops via evaluation surveys
- Hold workshops at other locations

To increase the number of attendees at vocational aquaponics training workshops, Facebook can be utilized for workshop advertisements since none of the attendees responded that they learned about the program through Facebook. “Before” and “after” surveys can be utilized for constant improvement of workshops. A WPI CPE representative indicated that a successful workshop is well tailored to the audience, and administering questionnaires to attendees prior to the workshop can help to identify the audience of the program. Evaluation surveys administered after every workshop can provide immediate feedback to identify areas in need of improvement.

Follow up evaluation surveys administered via email after programs can track attendees' steps taken towards joining the aquaponics industry.

The above recommendations have a focus on both market interest and education through their vocational workshops. By implementing both sets of recommendations Agroponicos can help foster the expansion of the aquaponics industry in Puerto Rico, providing a larger supply of local, organic, and GMO-free food options and supporting the economy through new local businesses and reduced food import rates.

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- Beatriz Arsuaga, Puerto Rico Project Site Local Coordinator.

Authorship

Timothy Granger

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2.5 Professional Education Involving Aquaponics
3.2.2 Research Question A
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Katherine Newell

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Kyla Wesley

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Paige Westlake

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Team

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1.0 Introduction

Over the past several decades, the agriculture industry weakened throughout Puerto Rico due to urbanization and industrialization. This change occurred with the transition from an agriculture-based society, with cash crop plantations sustaining the economy, to a service-based society. In 1956, the manufacturing sector generated more income than the agriculture sector for the first time in Puerto Rico's history. (Department of Latin American and Puerto Rican Studies, 2002)

Puerto Rico is currently facing economic challenges. The agriculture industry has deteriorated to only 0.5% of the gross domestic product (GDP) as of 2010 and 2.1% of the labor force. The decline in agriculture on the island coincides with the recent rise in import rates. Puerto Rico's imports totaled $46.58 billion in 2012, with food as one of the major imported commodities (Central Intelligence Agency, 2013). Furthermore, a staggering 85% of Puerto Rico's food supply was imported as of 2011 (Fuentes Escalante, 2009). A lack of arable land on the island contributes to these issues; only 4% of the land area is farmable compared to 18% in the United States (Central Intelligence Agency, 2013). An additional economic issue that Puerto Rico faces is the unemployment rate, which was reported at 14% in December 2012 (United States Department of Labor, 2013). A possible solution to these economic conditions is to expand the agriculture industry in Puerto Rico through non-traditional farming methods. Puerto Rico could benefit from an evaluation of the growth potential for the agriculture industry through these methods.

Aquaponics is a non-traditional farming method utilizing water and fish instead of soil to grow crops. This method combines aquaculture, or fish farming, with hydroponics, a soilless farming method, to produce vegetables, fruits, herbs and fish. Aquaponic technology is

sustainable and generally produces organic food products. Crops produced in aquaponic systems can also be free of genetically modified organisms (GMO- free) (Diver, 2006). Aquaponics provides a possible solution to the economic problems the territory is facing.

Agroponicos Cosecha de Puerto Rico, Inc. implemented aquaponic technology in Puerto Rico and has successfully sold produce since beginning operation in August 2012. The company plans to expand the aquaponics industry across the island by reaching out to the community to raise awareness of aquaponic technology and the food products grown through this system. Agroponicos' two main foci are profitable production and education. The market for food products grown in aquaponic systems depends on the community's knowledge of and willingness to buy local, organic, and GMO-free food products. Agroponicos also aims to provide aquaponics education by teaching the technology at vocational programs and workshops, mainly in Puerto Rico. The company believes that the general Puerto Rican population is not familiar with aquaponic products and technology and the economic and health benefits these systems could provide (Casas, Casas, & Casas, 2013). To address these issues, we defined the project in two main objectives:

1. Assessment of the market for local, organic and GMO-free food products to represent the market interest for aquaponics.
2. Evaluation of aquaponics education, specifically a one-day vocational workshop.

Before this project was initiated, no substantial research was available on market interest for local, organic and GMO-free food products in Puerto Rico. Our team investigated means to overcome this lack of knowledge by first addressing project objective number one, assessing market interest for aquaponic products. These data are necessary to discover the opportunities for expansion of the aquaponics industry. To obtain these data surveys and an interview were used,

focusing the research in the San Juan region. One survey assessed the knowledge of and interest in organic and GMO-free food products within the Puerto Rican community, including locals and tourists frequenting restaurants, grocery stores, farmers markets, and other populated areas. A second survey was distributed to managers and chefs of restaurants to evaluate their current use of and interest in local, organic and GMO-free food products. Similarly, a third survey was distributed to grocery store managers and produce managers. In addition to surveying, an interview was conducted with a local chef who is passionate about the agriculture industry in Puerto Rico and the use of local, organic, and GMO-free products. Data collected through the surveys and the interview were analyzed to provide an overview of the market potential for aquaponic products in Puerto Rico.

There was also no available evaluation of aquaponics educational programs. Without formal assessment, there is a lack of information on the effectiveness of teaching techniques and learning objectives. Project objective number two was addressed by focusing on a one-day vocational workshop at Caribe Fisheries in Lajas, Puerto Rico. An interview was conducted with the guest aquaponics instructor from Agroponicos to identify objectives for the program. Surveys were distributed to workshop participants for an evaluation of their experience with the program. Understanding the effectiveness of education in aquaponics helped us recommend possible improvements for the program. Overall, the research performed and the recommendations made could lead to enhanced community interest in aquaponics and eventually help improve Puerto Rico's suffering economy.

2.0 Background

2.1 Overview

Poor farmland conditions and stigmas associated with farming have deeply affected the agriculture industry in Puerto Rico. Innovative farming technology holds the potential to revitalize the agriculture industry. Specifically, the integration of aquaponics in the industry presents an opportunity to benefit the economy (Enduta, Jusoh, Ali, & Wan Nik, 2011). Other aquaponic systems in the United States and the Caribbean previously implemented have shown multiple challenges and benefits associated with the technology. A successful aquaponics industry in Puerto Rico requires two main components:

1. A market for food products grown in aquaponic systems.
2. Business owners and a workforce educated about aquaponic technology for the operation of aquaponics businesses.

There is a potential market for produce grown through aquaponics in Puerto Rico and there are some existing aquaponics workshops available on how to effectively operate an aquaponic farm. Further research is necessary to understand the opportunity for the aquaponics industry to grow.

2.2 Aquaponic Technology

Aquaponics is an innovative agriculture technology that utilizes hydroponic technology combined with aquaculture. Hydroponic agriculture is the science of growing plants in water or nutrient solutions instead of soil (Benton, 1977). Aquaponics differs from hydroponics in that it specifically uses aquaculture, or fish farming, as the source of nutrients for the plants. The plants grown through aquaponics can be organic and GMO-free (Diver, 2006).

The aquaponic cycle begins with farm-raised fish, usually tilapia or yellow perch, located in a rearing tank. Waste products from the fish are excreted and the resulting wastewater enters a filtration system that removes fecal matters from the wastewater. The water is then gravity or pump-fed into gravel beds where toxic waste products are broken down by bacteria and transformed into nitrogen, a key ingredient for plant development. The water then enters the hydroponic tanks where the plants are arranged to grow. Once the nutrient-rich water is absorbed by the plants, the water is filtered by the plants and transported back to the fish tank where the cycle repeats (Diver, 2006). Nutrient removal from the aquaculture wastewater is essential to the plant development because it protects the water from eutrophication and allows for reuse of the treated water (Enduta et al., 2011). The symbiotic relationship between the fish and the plants is the driving force for aquaponic technology. As with any farming system a favorable climate is necessary for crop growth, and some systems may require greenhouses or heaters to achieve the appropriate conditions (Panwar, Kaushik, & Kothari, 2011).

Figure 2 illustrates the components of an aquaponic system. The system depicted is a widely adopted model originally developed by Dr. James Rakocy at the Agricultural Experiment Station at the University of the Virgin Islands (UVI) (University of the Virgin Islands, 2013).

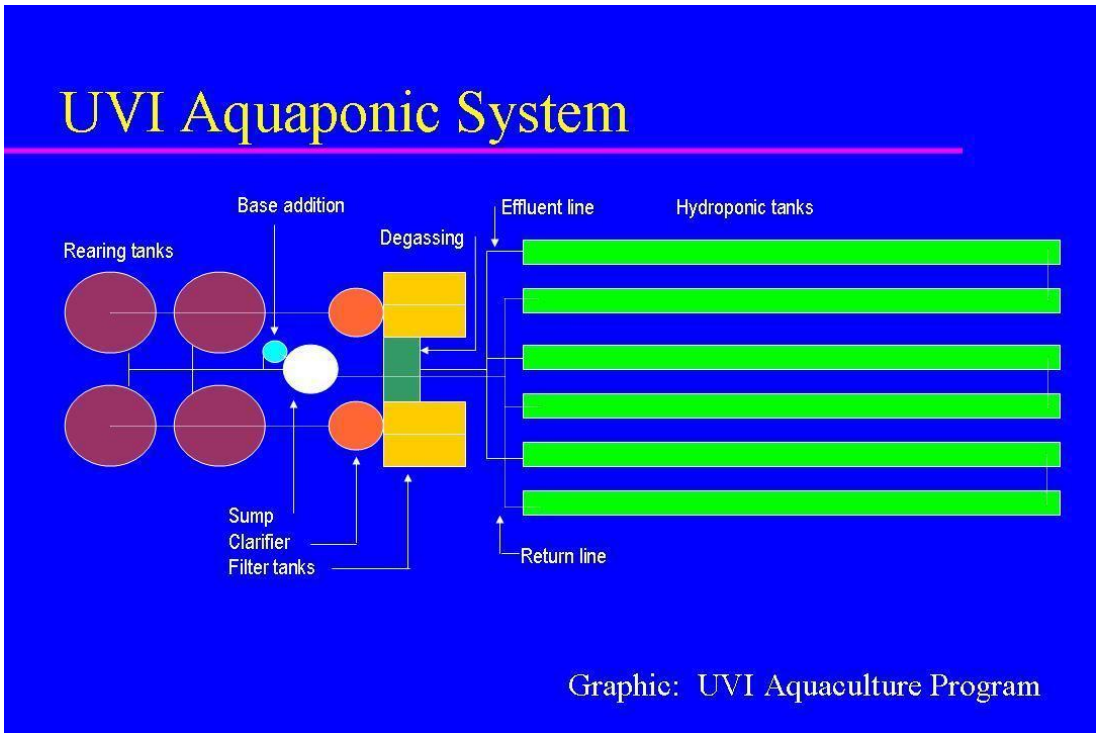

Figure 2: Graphical representation of an aquaponic system designed by Dr. James Rakocy (University of the Virgin Islands, 2013)

Dr. Rakocy, considered by some as the "father of aquaponics," was the director of the UVI Agricultural Experiment Station until his retirement in 2011. He developed the non-patented raft system of aquaponics where plant seedlings float on rafts in hydroponic beds with their roots exposed to the nutrient-rich water. Tilapia is his preferred fish species for the rearing tanks because they tend to live in large groups in the wild and can be raised in a small area, a necessity for aquaponic systems. Even though tilapia is the fish of choice, any fish that lives in large groups can be utilized in an aquaponic system. (Shea, 2010)

Aquaponics can be an efficient agriculture technique. According to Dr. Rakocy, 11,000 pounds of fish and 14,000 pounds of produce can be harvested in one year on 1/8 of an acre of land using his aquaponic method. Additionally, the UVI system is capable of conserving up to 97% more water compared to traditional farming techniques. The aquaponic system developed by Dr. Rakocy is a model used by many aquaponics companies. (Shea, 2010)

2.2.1 Aquaponics and Hydroponics in the United States

In the United States, aquaponic and hydroponic farms are becoming more widespread. In this section, three example aquaponics companies in the United States and their applications of technology and community involvement are discussed.

One company that utilizes Dr. Rakocy's aquaponic research and techniques is Nelson and Pade Inc. in Madison, Wisconsin. The company focuses on education and promotion of aquaponic technology. They sell vegetables and fish to consumers at farmers markets, but also host year-round workshops to teach about aquaponic systems and how to implement them. The business has expanded to sell equipment for aquaponic systems as well. Owners Rebecca Nelson and John Pade are involved with community projects and missions coinciding with their goal to feed the world. As one example, they provided produce to a food bank in Haiti, organized by a mission, to show locals how to provide food for themselves and decrease dependence on donations. (Burns, 2010)

In New Orleans there is an increase in demand for fresh produce but decreasing land area in the city. Aquaponic Modular Production Systems satisfies the high demand for fresh, local, and organic food in the urban area by using aquaponic technology to harvest over forty pounds of produce per week ("Aquaponic Modular Production Systems Unveils Aeroponic Farm in New Orleans," 2012). SkyyGreens in Chicago takes a slightly different approach to a similar problem. Graduates of the University of Chicago's Booth School of Business started the first indoor vertical aquaponics farm in the city, a new alternative for "urban farming." Their aquaponic design is unique because it utilizes vertical hydroponic beds, as shown by the example in Figure 3. ("Chicago Chooses SkyyGreens Aquaponics as Its 1st Licensed Indoor Farm," 2012)

Figure 3: Vertical growing bed at O'Hare Urban Garden in Chicago's O'Hare Airport (Mackie, 2012)

2.2.2 Aquaponics and Hydroponics in the Caribbean

Caribbean islands offer a unique climate for farming. The year-round warm weather provides favorable conditions for crop growth. However, Caribbean islands face environmental challenges including limited natural resources, limited land area, and pronounced wet and dry seasons. Isolation makes sharing resources along with importing and exporting commodities more difficult and expensive (Pulwarty, Nurse, & Trotz, 2010). Hydroponic and aquaponics farms are becoming more popular in the Caribbean because these systems succeed in locations with these qualities. Hydroponic gardens date back to the 1950s in the Bahamas, acting as a tourist attraction and helping supplement the island's imported produce with fresh, locally grown vegetables (Harrison, 1950). Since then, hydroponic technology has continued to grow. However, aquaponics companies in the Caribbean are limited.

Some Caribbean cruise lines and resorts are incorporating hydroponic gardens as attractions and also as a source of fresh produce for use in their kitchens. El Conquistador Resort

and Las Casitas Village, both Waldorf Astoria Resorts in the Caribbean, incorporate fresh vegetables and herbs grown in hydroponic systems into their meals. The CuisinArt Resort and Spa in Anguillais was the first Caribbean resort to include an on-site hydroponic garden. (Welly, 2011)

Village Farms, a hydroponic vegetable company based in the United States, established partnerships with Canada, Mexico, and key growers in the Caribbean. The company takes a different approach from many other hydroponic or aquaponic growers because products are packed and preserved for export to the United States instead of sold locally. (Ruffini, 2011)

Despite the environmental challenges limiting traditional farming, some companies in the Caribbean are finding alternative ways to maintain an agriculture industry. Hydroponic technology has been growing in popularity, but aquaponic technology is still relatively unexploited.

2.3 Organic and GMO-free Food Products

In aquaponic systems, organic classification for food products is dependent on the supplemental nutrients added to the system and the type of fish feed used in the rearing tanks. Most aquaponic systems utilize natural materials to produce organic food products. Fish can be classified as "organic" if they are fed an organic fish feed, but fish classification is independent of the produce classification. Organic crops are classified by the United States Department of Agriculture (USDA) as crops grown in farm conditions with appropriate levels of irrigation, sewage sludge and synthetic fertilizers. They also do not use prohibited pesticides or GMOs (Department of Agricuture, 2013). Traditional organic crop development relies on crop rotation, plant and animal manures, some hand weeding, and biological pest control. In non-organic

farming, pesticides may be used to protect plants from insects, disease and other damages (Mansour, 2012).

In some aquaponic systems, GMO-free seeds are used resulting in GMO-free products, one of the stipulations of organic (Department of Agricuture, 2013). A GMO product is classified as any organism that is altered by genetic engineering. Genetically modified (GM) crops are genetically altered in specific ways that are beneficial for agriculture production. Two of the main reasons for developing GM crops were to reduce the use of detrimental agrochemicals and to protect crops from insects. Other explanations for the development of GM crops include countering biotic constraints, such as weeds, pests and diseases; and helping to alleviate the stress of abiotic constraints, such as drought, salinity, cold and flooding. (Christou & Capell, 2009)

There are both advantages and disadvantages to organic and GMO-free food products. Pesticide use associated with non-organic farming can be detrimental to the environment. A report shows that only 10-15% of all pesticides used on farms and other agriculture systems reach the intended target—the plant or crop. The remaining 85-90% of the pesticide enters the soil, air, water or the person who is applying the pesticide. Contamination can be caused by pesticides in the soil, which can damage the fertility of the soil or be washed away by water sources. Unintended airborne pesticides can also be harmful to humans and wildlife in the surrounding areas. (Mansour, 2012)

Some consumers believe that a significant advantage associated with organic food products is health benefits. By avoiding the use of chemicals and pesticides, they believe the product is healthier and safer to consume. The most common cause of pesticide contamination is through food intake (Mansour, 2012). This issue is especially important to those who are

pregnant or nursing because pesticides can have negative effects on the development of fetuses and small children. Pesticides can also be extremely harmful to children with asthma or other chronic diseases. The average American child is exposed to ten to thirteen pesticides daily, which can increase the risk of developing cancer. The amount of pesticides humans ingest can be reduced by consuming organic foods. ("OP March/April 2012 Cover Story," 2013)

Some reports, including a scientific study on corn growth performed in 2003, have claimed that organic produce contains higher concentrations of certain nutrients, minerals, and naturally occurring antioxidants (Lester, 2006). However, there are also disadvantages of organic food products that can potentially cause health issues. Organic farming can cause contamination, bacteria, and increased levels of natural pesticides that are potentially as hazardous as synthetic chemicals (Mansour, 2012).

Some consumers believe that there is a difference in taste and quality of organic versus non-organic food products. According to a study on consumer's attitudes towards organic foods, both frequent organic consumers and non-organic consumers reported that organic fruits and vegetables taste better. Taste is also dependent on the shipment process of the product. In addition to better taste, organic food products have been reported as having higher quality than non-organic products due to freshness and nutrient content. (Ott, Misra, & Huang, 1991)

There are also advantages and disadvantages associated with GM crops, although the information is controversial. GM crops help increase food production while reducing the use of synthetic agrochemicals (Christou & Capell, 2009). Conversely, GM crops can cause field-evolved insects to adapt to the insecticidal proteins, the evolution of herbicide-resistant weeds, the killing of non-target arthropods, and potential risks to human health (Christou & Capell,

2009). Other problems with GMOs include decreasing biodiversity and contamination of non-modified crops through cross pollination (Rees, 2006).

The availability of organic produce and the convenience of purchasing produce are major factors in determining a consumer's shopping decisions. Based on Agroponicos' observations, organic food products grown in Puerto Rico have an advantage over organic products imported from the United States, which are particularly expensive due to import costs and seasonal farming effects (Casas et al., 2013). Another setback in Puerto Rico is the lack of farms in general, including organic farms. Organic farmers tend to produce smaller amounts of food which causes a lack of supply (Benet, 2013).

2.4 Market Interest for Aquaponic Products

Restaurants and grocery stores are two main channels of distribution that provide a potential market for aquaponic food products in Puerto Rico. There are a high volume of restaurants in the San Juan region, over 650 restaurants including chains from the United States (Fox, 2013; United States Census Bureau, 2012). Areas of interest within San Juan include Condado, Cupey, Guaynabo, Hato Rey, Isla Verde, Miramar, and Old San Juan. Traditional Puerto Rican cuisine contains imported fried foods and is usually void of vegetables. However, Puerto Rico is undergoing a "restaurant renaissance." This trend in Puerto Rico is growing as more restaurants with healthy, organic choices are sprouting across the island (Fox, 2013). This movement is promising for the sale of healthier food including products grown in aquaponic systems.

Supermarkets provide another possible channel of distribution for aquaponic produce. Pueblo Supermarkets specifically advertise their wide varieties of fruits and vegetables from both Puerto Rico and across the globe. Pueblo also provides a line of organic food called Full Circle

among other natural and preservative-free options (Pueblo). Supermarcados Econo is also a chain supermarket on the island. With over forty years of business experience and fifty-eight locations, Econo is one of the leaders of the food industry in Puerto Rico, focusing on high quality at low prices (Econo, 2011). Other chain supermarkets in Puerto Rico include Discount Food Distributors Inc. and SuperMax. In addition to these supermarkets, Freshmart and La Hacienda are smaller high-end grocery store chains that provide opportunity for the distribution of aquaponic produce (Freshmart, 2013; La Hacienda Meat Center, 2013).

Farmers markets are another option for distribution of organic and GMO-free produce grown in aquaponic systems. There are two farmers markets in Puerto Rico by the name of Mercado Agroecologico, one located in Cabo Rojo and the other in Rincon. More items are sold in Cabo Rojo, but fruits, vegetables, and plants are sold in both. A farmers market is open twice a month at the Placita Roosevelt right outside of Old San Juan. Products found here include curly leaf and red leaf lettuces, arugula, spinach, potted plants and herbs, honey, probiotic yogurt, whole wheat baguettes, and a wide variety of other fruits and vegetables (Angelet, 2011). The Mercado Urbano at Ventana el Mar in Condado is held on the first Sunday of every month and contains over forty vendors. This market was designed to provide opportunities for local farmers and raise awareness of local and organic goods among Puerto Rican consumers. Mercado Agrícola Natural de Viejo San Juan and La Plaza de Mercado de Santurce are additional markets in San Juan, both open every day offering a variety of fresh, locally grown and organic products (Salach, 2012).

2.5 Professional Education Involving Aquaponics

Professional education and instructional programs can be used to teach a variety of skills to adults in the form of classes, workshops, and other informational sessions (LeBlanc, 2013).

For Puerto Ricans to enter the aquaponics industry, they must understand the technical skills and business aspects necessary to operate an aquaponics farm.

2.5.1 Basic Elements of an Instructional Program

There are general guidelines that every educational and instructional program should follow regardless of the program's purpose. Eight basic criteria that an instructional program, workshop, or seminar should meet are listed below. The criteria are framed as questions instructors or program directors could ask themselves to develop or evaluate a program (Williams, Brown, & Certo, 1975):

I. "What skill does a teacher intend for the student to perform (What does a teacher intend to teach the student)?
II. "Why does a teacher want the student to perform a specific skill?
III. "How does a teacher intend to teach the student to perform a skill?
IV. "How can a teacher empirically verify that the skill of concern is being or has been taught?
V. "Can the student perform the skill at a situationally acceptable rate?
VI. "What does a teacher intend to use as vehicles (instructional materials) for the skill to be acquired and performed?
VII. "Can the student perform the skill across:

    a. Persons;
    b. Places;
    c. Instructional materials;
    d. Language cues?

VIII. "Can the student perform a skill without directions to do so from persons in authority?"

These guidelines are only a starting point in creating a program and are likely to expand according to the specific situation, but they offer guidance and ensure the goal of the program is met. Identifying the skill set to be learned in the program, the motivation or reason for the program, and the method in which it will be learned (for example, a lecture, a hands-on program, an online tutorial, a group or individual project, etc.) gives structure and purpose to the program.

An effective instructional program also involves task analysis: establishing the allocation of skills within an area of study and dividing the skills into parts, ordered from simplest to most complex. (Williams et al., 1975)

The success of an instructional program is dependent on the instructors and the atmosphere they create. Instructors passionate about their work enable the attendees to be fully engaged in the material. An instructor should avoid spending more than forty-five minutes lecturing without audience participation such as a discussion or activity because the group could lose interest and enthusiasm. It is equally important for the instructors to know their audience because workshops should be tailored to the group's goals, knowledge, size, and interest. Understanding the goals of the workshop is the most important component of a focused instructional program. Depending on the type of workshop, smaller group sizes are typically beneficial because they allow the attendees to engage in a hands-on and personal experience. More time should be spent on hands-on learning if the audience is experienced, while more time should be spent on lecturing if the audience is new to the material. An evaluation of the program is an important final step for constant improvement of the quality of the workshop. (LeBlanc, 2013; Wright, 2013)

2.5.2 Assessment of an Instructional Program

The purpose of evaluation is to determine worth or quality based on a certain criteria. Two types of evaluation include formative and summative evaluation. Formative evaluation is used to provide instructors information to improve the program. Summative evaluation provides information regarding the worth or merit of the program and is made public for program decision makers and potential program participants. The types of evaluation are conducted for different

audiences, but both are needed for program improvement. A table explaining the differences between these two types of evaluation can be seen in Table 1.

Table 1: Differences between formative and summative evaluation (Worthen, Sanders, & Fitzpatrick, 1997)

	Formative Evaluation	**Summative Evaluation**
Purpose	To determine value or quality	To determine value or quality
Use	To improve the program	To make decisions about the program's future or adoption
Audience	Program administrators and staff	Program administrators and/or potential consumer or funding agency
By whom	Primarily internal evaluators, supported by external evaluators	External evaluators, supported by internal evaluators in unique cases
Major Characteristics	Provides feedback so program personnel can improve it	Provides information to enable program personnel to decide whether to continue it, or consumers to adopt it
Design Constraints	What information is needed? When?	What evidence is needed for major decisions?
Purpose of Data Collections	Diagnostic	Judgmental
Measures	Sometimes informal	Valid and reliable
Frequency of Data Collection	Frequent	Infrequent
Sample Size	Often small	Usually large
Questions Asked	What is working? What needs to be improved? How can it be improved?	What results occur? With whom? Under what conditions? With what training? At what cost?

Program employees conduct internal evaluations, while outsiders conduct external evaluations. The main difference between these evaluations is the amount of knowledge the evaluator has about the program; both perspectives are necessary for improvement (Worthen, Sanders, & Fitzpatrick, 1997).

The three main steps in evaluating a program are the following:

1. "determining standards for judging quality and deciding whether those standards should be relative or absolute
2. "collecting relevant information, and
3. "applying the standards to determine value, quality, utility, effectiveness, or significance."

Evaluation is a necessary step to understand if the program is achieving its expected goals. (Worthen et al., 1997)

2.5.3 Existing Aquaponics and Hydroponics Programs

There are multiple existing programs designed to teach aquaponic skills. This section describes five different examples of aquaponics and hydroponic vocational programs.

1. University of the Virgin Islands Agricultural Experiment Station at St. Croix

At the University of the Virgin Islands on the St. Croix campus, the Agricultural Experiment Station (AES) conducts scientific research to improve the efficiency of agricultural methods on the Virgin Islands and in the Caribbean region. The station is dedicated to preserving natural resources, exploring innovative agricultural technology, and improving and expanding the agriculture industry. The AES specializes in aquaculture and aquaponic systems. In addition to research, workshops are offered to teach aquaponic technology. Each workshop covers a wide variety of topics such as:

- Aquaponic Systems: System design, management, and construction.
- Operation of Aquaculture (fish production and upkeep): Monitoring and maintaining water quality; feeding and nutrients, growth and survival; harvesting and processing.
- Plant Production and Maintenance: Seeding, insect control, harvesting and packaging.
- Economics: Budgeting, marketing, and planning.

The aquaponics workshop is organized as a three-day course, with each day split up into 50% classroom lectures to introduce the theory and 50% hands-on learning for practical application. Presentations are used to teach the science of the technology and fieldwork including fish handling, vegetable production, operation of the aquaponic system, and laboratories utilizing water quality monitoring equipment. Each participant is provided with a USB flash drive containing course materials and important information. For this program, online registration is required at a cost of $600. (University of the Virgin Islands, 2013)

2. Aquaponics Institute

The Aquaponics Institute in Pescadero, California is an organization promoting aquaponic technology and the aquaponics industry. They promote the technology to expand the aquaponics community and offer support for aquaponics companies. In addition, they provide training sessions to teach aquaponic technology. The Aquaponics Institute programs are different from other workshops because they include a variety of international aquaponics professionals as instructors. These twelve instructors come from a wide range of backgrounds including different aquaponic methods, system sizes, and climate, adding diversity to the workshops. Pedro Casas Jr. of Agroponicos was recently added to the Aquaponics Institute staff. The five-day Intensive Aquaponics Commercial Farm Training conducted by the Aquaponics Institute at Ouroboros Farms, in Pescadero, California aims to expand the aquaponics community by teaching the effective startup strategy and maintenance of a successful aquaponics farm. Topics covered throughout the program include aquaponics basics, plant and fish care requirements, insect management, beneficial bacteria, plumbing in an aquaponic system, energy efficiency of artificial lighting and heat, water chemistry, farm management, and sales and marketing. The topics are divided into eleven classes, six hands-on workshops, and four ninety-minute

presentations. While classes go in depth with material, hands-on workshops allow for interactive learning. Workshops included with the program consist of facility tours, the building of small and large scale systems, daily operation of an aquaponics farm, and creating compost. A unique aspect of this program is the included meal plan. Three meals prepared with produce from Ouroboros Farm are provided per day. The total cost of the five-day program is $1,490 per person or $2,780 per pair (Cosmo, 2013). The five-day Intensive Aquaponics Commercial Farm Training will be held at Agroponicos in November 2013 (Casas et al., 2013).

3. "5E" Plan: NASA Biologists

A case study was completed at a West Virginia high school by NASA biologists in 2011 focusing on the development of a hydroponic system. This program employed the "5E" plan: Engage, Explore, Explain, Elaborate, and Evaluate. The "5E" plan was developed and is still used by the Biological Sciences Curriculum Study. The "Engage" stage involves prompting the students to think about and discuss sustainable life forms. The discussion is then narrowed to sustainable food production and hydroponic food systems. The biologists also discussed factors that affect plant development and health including temperature and pH. The "Explore" stage focused on the experiment, which was developed to test temperature change and the effect it had on plant growth. Students were split into small groups and given responsibilities, allowing all participants to be involved. In this process they also examined the chemistry of the project. In the "Explain" and "Elaborate" stages the students measured the plants to observe how temperature change affects plant growth, biomass, and root to stock ratio. In the final "Evaluate" stage, the instructors analyzed what they accomplished with the students and what knowledge and skills the students gained from the project. The instructors saw an increase in knowledge and

understanding of biology and chemistry, especially relating to plant anatomy. There was also an increase of interest in the subject matter. (Carver & Wasserman, 2012)

4. Culinary Arts & Aquaponics

Another interesting program used to promote aquaponic technology and produce is a culinary arts program at the Colombia Area Career Center in Missouri. This program utilizes a state-of-the-art kitchen with an in-kitchen aquaponic system. The classes teach cooking skills, the science of aquaponic technology, and the benefits of cooking with fresh organic food. Both tilapia and fresh herbs are used in the dishes prepared. (Nelson & Pade, 2007)

5. Aquaponics Workshop at Caribe Fisheries in Puerto Rico

Pedro Casas Jr. of Agroponicos currently co-teaches with Dr. Mike McGee, owner of an aquaculture farm called Caribe Fisheries in Lajas, Puerto Rico, at a one-day vocational workshop. The workshop is held every two months at Caribe Fisheries and is considered an introductory program to aquaponics and aquaculture. The predominant focus of the project is on the aquaponics portion of the workshop where information about the new technology, the opportunities in aquaponics, and the skills needed to join the growing agriculture industry in Puerto Rico is taught. The program is designed to gauge participant's interest in aquaponics and the possibility of starting an aquaponic system or company (Casas et al., 2013). The two overall goals of the workshop are:

1. Encourage participants to attend more in-depth trainings for detailed information on aquaponic systems including construction, maintenance, production, and marketing.
2. Spark interest in the participants, leading them to improve or build a system.

These two overall workshop objectives could lead to the expansion of the aquaponics industry. (Casas et al., 2013)

2.6 Agroponicos Cosecha de Puerto Rico, Inc.

Agroponicos Cosecha de Puerto Rico, Inc. is a relatively new company on the island utilizing aquaponic technology to grow fresh produce. The company is owned and operated by the Casas family; Pedro Sr., Pedro Jr., and Jorge. Agroponicos began production within the past year and has sold crops from their system since August 2012. Agroponicos' aquaponic system is modeled after the UVI system and includes two large fish rearing tanks that gravity-feed six hydroponic beds for crop development. For their major crop, lettuce production requires six weeks. Seedlings are grown in a three week cycle and are then placed in Styrofoam rafts that float in the beds for the remaining three weeks. The entire growth cycle of a plant can be seen in one row because the rafts are moved through the hydroponic beds in stages. No greenhouses or heaters are required in Puerto Rico's favorable climate. A covered structure enclosed with netting surrounds the area designated for the process. The system also includes filtering tanks and rain-collecting tanks to limit the need for fresh water. Figure 4 displays the specific system being used at the Agroponicos farm. The open shed in the image houses the fish rearing tanks, clarifying tanks, filter tanks, and other machinery required for the system.

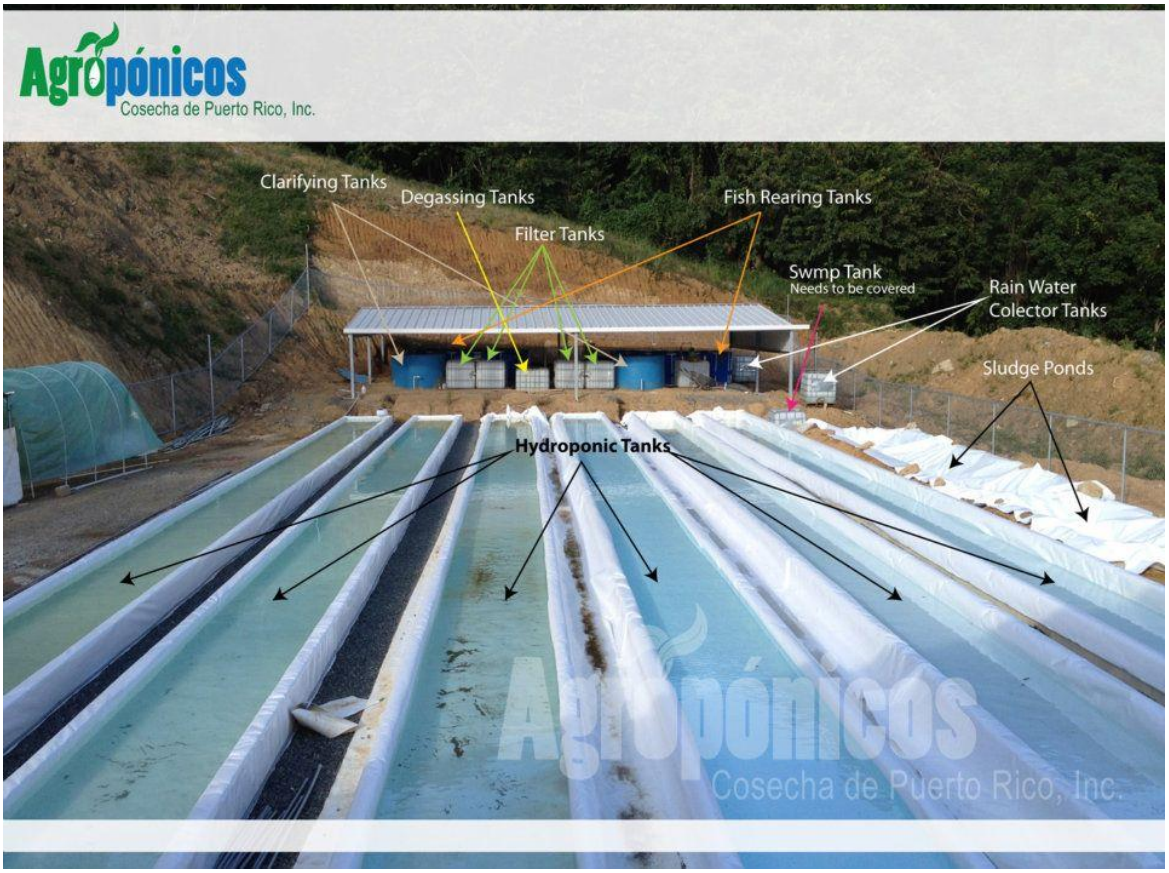

Figure 4: Aquaponic system at Agroponicos Cosecha de Puerto Rico, Inc. Netting that encloses this entire structure is not shown. (Photo courtesy of Agroponicos)

In the past nine months of the company's production, Agroponicos has experimented with growth of several crops including a variety of lettuce, herbs and tomatoes. They have identified the crops that are the easiest to grow and have a relatively quick growing period of about six weeks. Based on this experimentation their goal for the near future is to increase production of lettuce and begin production of chives, as they are not currently utilizing all six hydroponic beds in their system. No fertilizers or pesticides are used, resulting in organic produce. GMO-free seeds are used for crop production, meaning the crops are not artificially genetically engineered. Agroponicos is not currently certified organic by the USDA, but advertise their products as grown with GMO-free seeds and without pesticides or chemicals, as shown in the product label for their lettuce in Figure 5.

Figure 5: Bohiti brand label for Agroponicos products (Photo courtesy of Agroponicos)

One competitor for Agroponicos is Hidroponicos Del Pais, a producer of hydroponic lettuce in Puerto Rico. Other competitors include organic and traditionally farmed lettuce distributors in the United States exporting their crops to Puerto Rico. Agroponicos currently sells their products to twelve clients consisting of high-end restaurants and grocery stores. The company does not currently focus on the production of fish and the fish they farm in the system are not brought to market. They hope to see not only their own company, but the entire aquaponics industry in Puerto Rico, expand. (Casas et al., 2013)

One avenue for expansion of the aquaponics industry that Agroponicos would like to explore is the sale of small-scale aquaponic systems for restaurants. These systems could be set up on rooftops or in other available areas of restaurants. Agroponicos would either fully service the system or train restaurant employees to service the system, conveniently providing chefs with fresh, organic and GMO-free food products. (Casas et al., 2013)

Owners of Agroponicos believe that the Puerto Rican community is becoming more aware of the foods they consume. The company also believes the community is interested in reading food labels and finding out how ingredients can affect their health (Casas et al., 2013). Agroponicos is interested in discovering the opportunity for aquaponics to flourish on the island through evaluating interest in the market for organic and GMO-free food products and assessing aquaponics education.

3.0 Market Interest

3.1 Market Interest Methods

The market interest for food products grown through aquaponics was assessed to evaluate the opportunities for this new agriculture technology to expand on the island including the expansion of Agroponicos as they aim to produce at full potential utilizing all six hydroponic beds. One of Agroponicos' main objectives is production and sales. Consumer patterns are an important aspect of the market interest because consumers drive demand. We investigated the interactions within the supply chain. Agroponicos and future aquaponics companies are producers who sell to restaurants and grocery stores who, in turn, distribute to consumers.

Restaurants and grocery stores offer opportunities for expansion of the aquaponics market. Agroponicos specifically expressed interest in the possibilities for growth in these two channels of distribution. We investigated the community's interest in organic and GMO-free products in restaurants and grocery stores to help determine the market for food grown through aquaponics.

3.1.1 General Survey Content

To understand the overall knowledge and interest in these products across the island, we used surveys, interviews and team observations in the San Juan region of Puerto Rico. Three surveys were created for consumers, restaurants and grocery stores, respectively. Each survey contained questions regarding organic and GMO-free products, focusing on knowledge about these products, purchasing tendencies, interest in purchasing or providing these products, and opinions on the advantages and disadvantages of purchasing or providing these products. Surveys contained questions on five-point Likert scales and multiple choice questions for quantitative data and simplified analysis, as well as open response questions to gain qualitative

information. The length of each survey was restricted to one page to increase participation and encourage completion of all questions. All surveys were reviewed by project advisors and the owners of Agroponicos. Additionally, the surveys were translated into Spanish by an owner of Agroponicos, and distributed in either Spanish or English depending on the point of contact's preference. To ensure a higher response rate, all surveys were administered in person in hardcopy. All data were analyzed in SPSS using correlations, t-tests, analysis of variance (ANOVA) and graphs.

3.1.2 Consumer Survey

We utilized surveys and our personal observations to assess the general public's awareness of and interest in organic and GMO-free food products, representing products grown through aquaponic farming. The survey questions were intended to gather information about the consumer's knowledge and willingness to purchase these types of food products. The majority of the survey was designed with a five-point Likert scale from "strongly disagree" (1) to "strongly agree" (5). An open response question was included allowing consumers to provide qualitative information about their purchasing patterns beyond what they expressed in the Likert scale portion of the survey. Demographic information was also requested for analysis purposes. The survey is provided in Appendix A. Consumers were surveyed in busy public plazas in Old San Juan, at three farmers markets in the San Juan region, at the Sagrado Corazon train station, and sidewalks in the Miramar district. These locations were chosen to reach a wide variety of consumers in a short amount of time. Consumers voluntarily completed the survey, and many provided us with additional information through informal discussion following their participation in the survey. A total of 106 surveys were administered and collected, a large enough sample size

for sufficient results analysis. The data provided the consumers' view of the market interest for food products grown through aquaponics.

3.1.3 Restaurant Survey and Interview

To further assess the market interest for the growing aquaponics industry, we evaluated how well organic and GMO-free food products are currently integrated into various types of restaurants in San Juan. We also evaluated restaurant interest in these food products. The survey, provided in Appendix B, contained some questions on a five-point Likert scale bounded by the descriptors "0%" (1) and ">30%" (5) to determine the amount and types of food purchased. The survey also included multiple-choice questions allowing participants to select all answers that could apply. The last question contained an open response component for participants to provide further insight as to why they would or would not want a small-scale aquaponic system for their business. We surveyed restaurant managers, owners, and chefs because they were the most knowledgeable and qualified staff members to answer the survey questions. Forty-seven restaurants were surveyed in Old San Juan, Condado, and Isla Verde to evaluate their current purchasing choices and interest in purchasing local, organic, and GMO-free food products. These locations could be reached by public transportation and had a high volume of restaurants in close proximity to each other, which enabled us to survey many restaurants in a short amount of time. To evaluate the market interest in different types of restaurants, three categories were used: "fast casual" for cafés and diners where customers often pay at the counter, "casual" for family restaurants and reasonably priced sit-down dinners, and "fine dining" for expensive, formal sit-down dinners. Restaurants were categorized based on team observations of the overall atmosphere and menu. Occasionally the survey led to a brief informal discussion, giving us a deeper understanding of the restaurants perspective on organic and GMO-free produce and fish

grown through aquaponics. These findings helped us evaluate restaurants as a potential market for aquaponic food products.

Upon surveying restaurants, a recommendation was made to contact Chef Wilo Benet, head chef and owner of Pikayo, a luxurious fine dining restaurant in the Conrad Condado Plaza in San Juan. His philosophy in the kitchen is to use products with exceptional quality grown domestically in Puerto Rico whenever possible. We arranged an interview with him to discuss his interest in using produce grown through aquaponics on the island. Questions were prepared prior to the interview and focused on his opinions as a native of Puerto Rico on the agriculture industry on the island, including the supply of organic and GMO-free foods and the stigma associated with employment in agriculture. The questions addressed consumer trends seen regarding food purchasing choices. We also planned to discuss any requests for local, organic, or GMO-free foods that Chef Wilo receives in his restaurant and any previous work done in support of the agriculture industry in Puerto Rico. Two team members attended the interview at Pikayo. A transcript of the interview is provided in Appendix C. This interview was beneficial because his ideas and opinions could be used for recommendations to Agroponicos.

3.1.4 Grocery Store Survey

We also evaluated the market interest for aquaponic food products in various grocery stores. The grocery store survey contained questions on a Likert scale identical to the scale used for the restaurant survey, a “mark all that apply” section, and an open response question. The survey questions were designed to discover the availability of organic and GMO-free food products in different types of stores and to understand customer habits and preferences regarding these food products. Eleven grocery stores in Condado, Guaynabo, Isla Verde, Miramar, Old San Juan and Santurce were visited and surveyed because travel to these locations was realistic.

General managers and produce managers of the stores were asked to complete a survey, provided in Appendix D. These managers were surveyed because they had the most knowledge about the products available in the store. Grocery stores were categorized into three types: supermarkets, high-end stores and corner stores, by observing the size of the store and the price and quality of the items sold. The combination of methods used to assess the market interest creates an overview of the opportunities, or lack thereof, for aquaponic companies to exist and flourish within the San Juan region.

3.2 Market Interest Results

3.2.1 Demographics from the Consumer, Restaurant and Grocery Store Surveys

Consumer, restaurant, and grocery store surveys were completed to assess the market interest in aquaponic products. One hundred six consumer surveys were completed. The distributions of their ethnicity, permanent residency and age are shown in Figure 6.

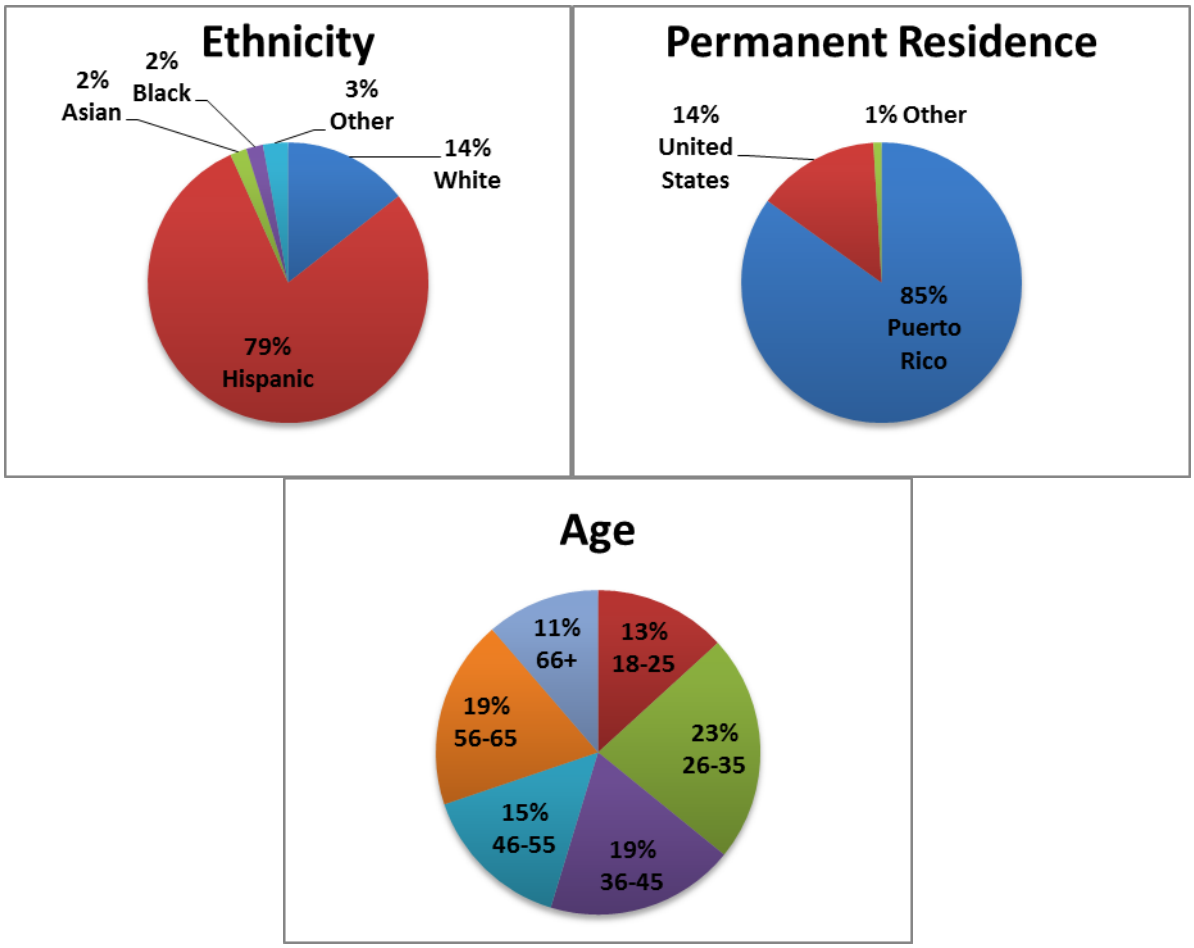

Figure 6: Consumer Survey- Demographic information of ethnicity, permanent residence, and age

Most citizens who completed the survey were of Hispanic race since the majority of participants lived in Puerto Rico. From this information, we were able to grasp what the Puerto Rican population understood about organic and GMO-free products. The percentages of each age group were fairly uniform allowing for a representative sample.

A total of forty-six surveys were gathered from restaurants within the San Juan area. Surveys were completed at thirty-four restaurants in Old San Juan and thirteen restaurants in Condado and Isla Verde. All restaurants were classified into three categories: fast casual, casual, and fine dining. The distribution of types of restaurants is displayed in Figure 7.

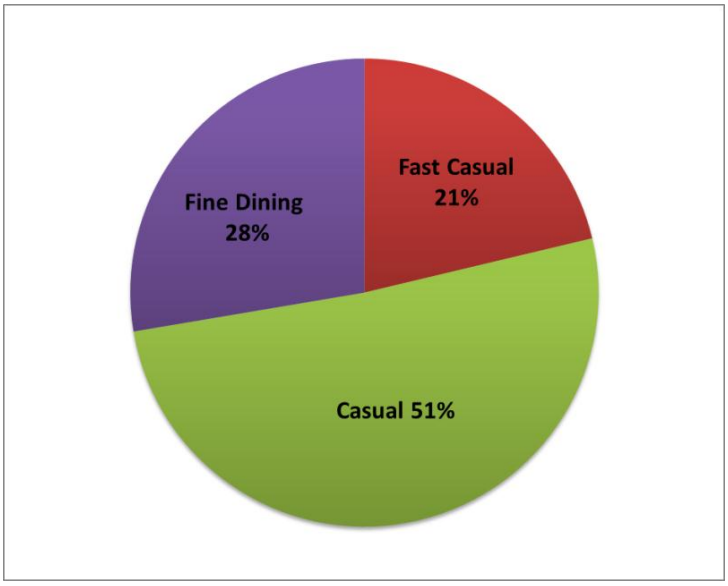

Figure 7: Restaurant Survey- Types of restaurants

These demographics enabled us to assess the organic and GMO-free knowledge based on the type and location of restaurants.

Eleven grocery stores were surveyed within the region of San Juan. Within each location the grocery stores were categorized by type of store: supermarket, high-end store, or corner store. The frequency of stores by type is shown in Figure 8.

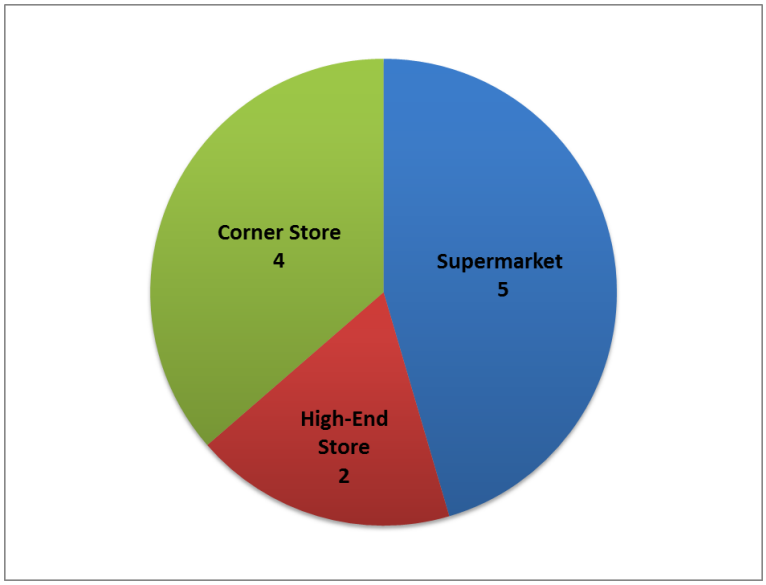

Figure 8: Grocery Store Survey- Number of grocery stores by type

All demographic information was utilized to understand the surveyed population and to effectively analyze our collected results. Full consumer survey, restaurant survey, and grocery store survey results are shown in Appendices E, F and G, respectively.

3.2.2 Research Question A: What is the community's knowledge about organic and GMO-Free Foods?

Our team focused on determining the community's knowledge about organic and GMO-free products. We then analyzed why and how knowledge levels are related between the three different surveys. Two questions from the consumer survey asked about a subject's basic understanding of organic food options and a basic understanding of GMOs. These questions were queried on a five-point Likert scale from "strongly disagree" (1) to "strongly agree" (5), and their responses are compared and shown in Figure 9 below.

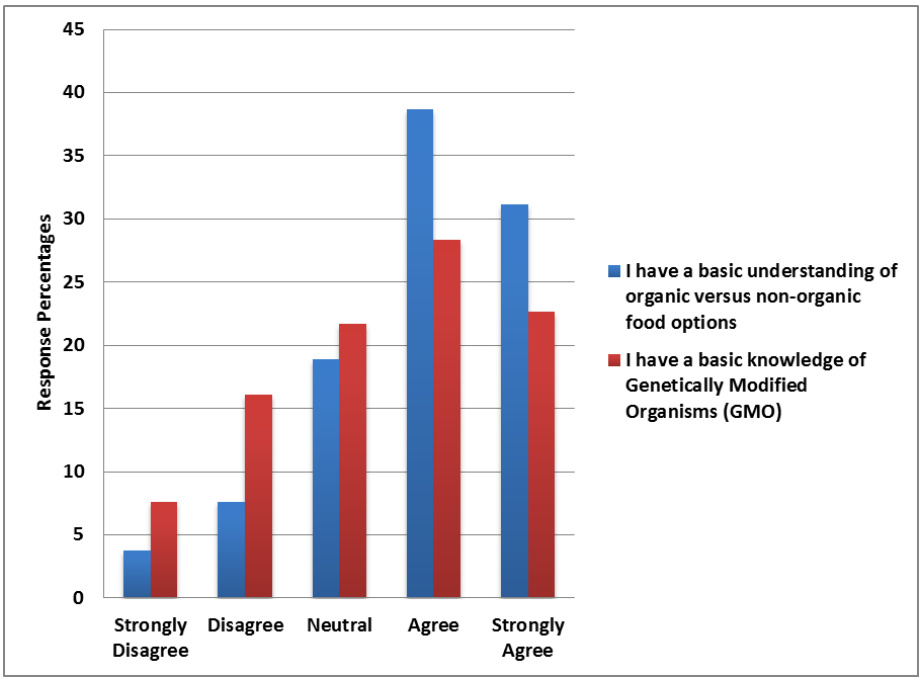

Figure 9: Consumer Survey- Basic knowledge of organic and GMO

The most popular answer for both basic knowledge of organic and GMO-free was "agree" indicating that the community has some understanding of the two types of produce. Seventy percent of consumers reported they "agree" or "strongly agree" to have a basic knowledge of organic versus non-organic food options. Fewer consumers were aware of genetically modified organisms, as only 51% agreed to have a basic understanding of GMO and some participants requested more information about the GMO-free classification. The Pearson correlation between the two questions was 0.450 ($p<0.001$). This significant positive correlation shows that more knowledge in organic foods is associated with more knowledge of GMO-free foods. A t-test was performed on consumers' basic knowledge of organic foods, comparing Puerto Rican residents to non-Puerto Rican residents. The test shows that non-residents have more knowledge of organic products with a mean of 4.50 versus those in Puerto Rico with a mean of 3.74 ($t=-2.694$, $p=0.008$). A larger mean value corresponds to more awareness due to the five-point Likert scale.

When a similar t-test was performed for consumer knowledge of GMO-free products there was no significant difference based on residency ($t=-1.086$, $p=0.280$).

Four different ANOVA tests were performed to compare knowledge of products between different demographic groups. The first two ANOVA tests compared basic knowledge of organic and GMO-free products between different age groups. There was no significant difference based on age for either knowledge of organic foods ($F=1.747$, $p=0.131$) or knowledge of GMO-free foods ($F=0.374$, $p=0.865$). The last two ANOVA tests analyzed the same questions based on ethnicity. There were no significant differences ($F=2.684$, $p=0.036$ and $F=2.393$, $p=0.056$, respectively).

Similar to interactions with consumers, many restaurant managers and chefs asked us about the meaning of GMO-free, indicating they are not aware of the modified foods they could be serving their customers. This lack of knowledge was further represented by the 26% non-responses for the survey question, "What percentage of the food you purchase is GMO-free?" In addition, some of the surveyed grocery store managers either did not understand what GMO-free meant or did not know the classification of their food products. Three stores out of eleven reported they do not know what percent of their produce sold is GMO-free.

Overall, the data collected via consumer, restaurant, and grocery store surveys provided our team with an understanding of the community's knowledge about organic and GMO-free products in consideration of the market interest for aquaponics. The community demonstrated a basic knowledge of organic products, yet evidence shows that the community has less knowledge of genetically modified organisms.

3.2.3 Research Question B: What is the consumer's willingness to buy organic and GMO-free Foods?

The market's willingness to purchase organic and GMO-free food products was investigated by integrating data from all three surveys and personal communication with the study participants. We contrasted two responses on the consumer survey, one related to purchasing organic foods and the other related to purchasing GMO-free foods, to observe which type of products the general public preferred. The results are displayed in Figure 10 below.

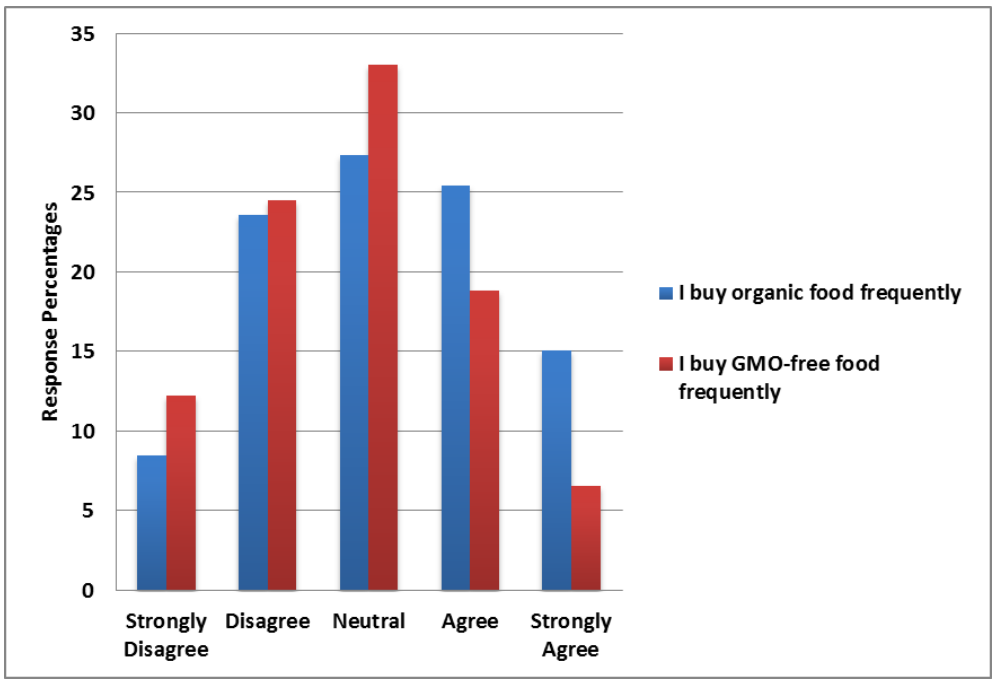

Figure 10: Consumer Survey- Purchasing of organic vs. GMO-free food

The most frequent answer on the five-point Likert scale was "neutral." Forty-three survey respondents agree they buy organic products, and twenty-seven reportedly buy GMO-free products. Of the twenty-seven consumers who buy GMO-free products twenty of them also buy organic, indicating the majority of consumers who buy GMO-free also buy organic. Conversely, of the forty-three consumer who buy organic twenty respondents answered they do not purchase GMO-free, so buying organic does not necessarily indicate a strong tendency to buy GMO-free.

Calculated results show a significant correlation (p=0.003) between consumer purchasing of organic products and purchasing of GMO-free products with a Pearson correlation value of 0.293. This correlation displays a positive relationship between purchase decisions for organic and GMO-free food products among consumers.

ANOVA tests and t-tests were also run on the consumer survey data based on demographics. There are no significant results that show differing purchasing tendencies of organic or GMO-free products based on race (F=1.193, p=0.318 and F=0.509, p=0.729, respectively). There is no statistical significance indicating purchasing patterns of organic or GMO-free products differ depending on permanent residence, whether the surveyed consumers lived inside or outside of Puerto Rico (t=0.457, p = 0.585 and t=1.270, p=0.207, respectively). There is also no statistically significant difference regarding purchasing patterns and age for organic foods and GMO-free foods (F=1.425, p=0.222 and F=0.438, p=0.821, respectively). Overall, consumers' choices to purchase organic and GMO-free products did not differ based on race, permanent location, or age.

On the restaurant survey, managers and chefs were asked what percentage of organic food, domestically grown food, and GMO-free food they purchase and the results are displayed in Figure 11 below.

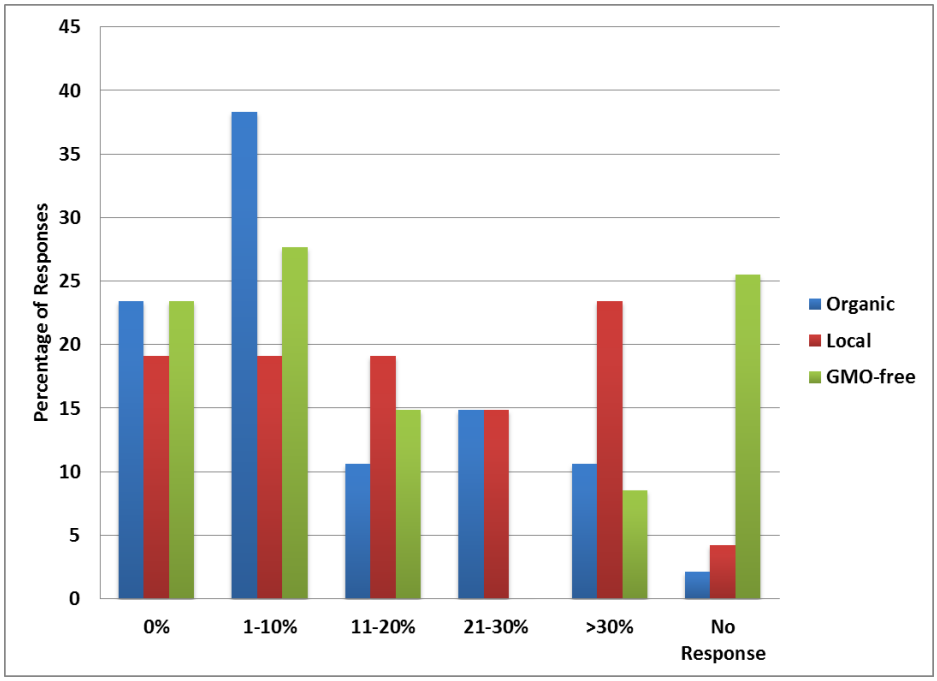

Figure 11: Restaurant Survey- Percentages of types of food restaurants are currently purchasing

The results show the most frequent response for organic and GMO-free purchasing is in the 1-10% range indicating that many restaurants have few organic and GMO-free products that they purchase for use in the restaurant. Only five restaurants answered that over 30% of the food they purchase is organic. Removing non-responses, the percentage of organic food purchased and percentage of GMO-free food purchased had a significant Pearson correlation value of 0.687 ($p<0.001$). This positive correlation displays that purchasing organic food is associated with purchasing GMO-free food. The distribution of the purchasing of locally grown produce varied among restaurants, but the majority, 23%, of surveyed restaurants reported purchasing more than 30% domestic products. This statistic, along with discussions with restaurant owners and chefs led us to believe that locally grown food products hold a stronger importance on the island than the classification of organic and GMO-free. In particular, Chef Wilo Benet was one of the strongest proponents of emphasizing locally grown food products in the market.

Using the grocery store survey, we investigated what food products had the highest demand in grocery stores between vegetables, fruits, herbs and spices, and fish. Although the survey question did not specifically ask about organic and GMO-free classification, the questions were targeted at products that can be grown through aquaponics. This information was gathered to determine which type of food products was in highest demand according to the stores. Six of the eleven surveyed grocery stores answered that vegetables were in highest demand, indicating a stronger market for this type of food. No stores reported fish as the product most in demand. A separate survey question analyzed *specifically* which food products that are proven to grow through aquaponics had the highest sales in grocery stores. Figure 12 reports the results in a histogram below.

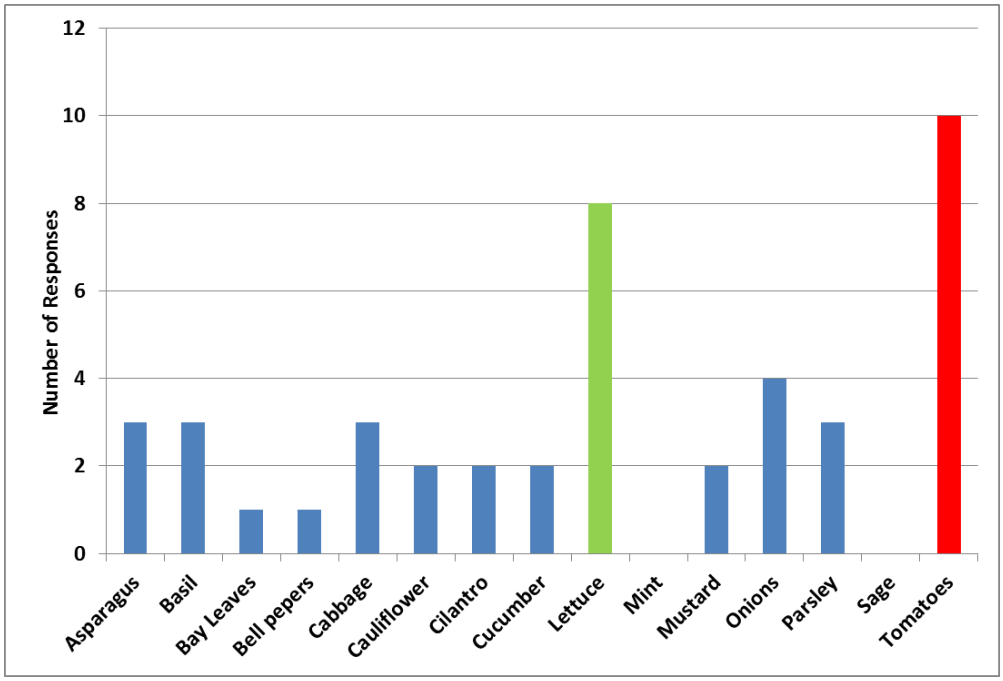

Figure 12: Grocery Store Survey- Sales of products effectively grown in aquaponic systems

Lettuce and tomatoes are the products reported to have the highest sales, indicating higher demand among consumers. Other products of note were mint and sage because no stores reported these items in high demand indicating minimal market interest.

Opportunities for organic and locally grown produce to flourish in Puerto Rico are apparent, but there is less interest in GMO-free produce based on the collective data above, specifically the lower responses for all questions about GMO-free products. There is evidence of potential for the market to grow if consumers, restaurants, and grocery stores can be educated and convinced to change their purchasing habits.

On each of the three surveys, a similar question was asked about the benefits of buying organic and GMO-free food products to understand the community's reasons for their purchasing habits. The question was phrased differently on each survey, which may have created a bias when comparing the surveys together. There were a lower number of responses for fill-in answers compared to answers provided for selection. Notice the restaurant survey has an overall low percentage of responses in this table because the question on this particular survey asked why or why not restaurants purchase organic and GMO-free food, and many chose to only answer why they do not purchase these products. It is also important to note the percentages from the grocery store survey could be misleading due to the small sample size of eleven surveyed stores. The comparative results for purchasing organic and/or GMO-free food products are shown in Table 2.

Table 2: Consumer, Restaurant, and Grocery Store Survey- Reasons for purchasing organic/GMO-free food products

	Consumer Survey (106 total)	Restaurant Survey (47 total)	Grocery Store Survey (11 total)
Health benefits	76%	6%	82%
Taste	41%	26%	0%
Quality	0%	4%	0%
Shelf life	28%	0%	18%
Value	15%	0%	9%
Availability	0%	0%	9%

Percentages shown are of the total number of participants for each survey. Taste was not chosen by grocery stores and this statistic was surprising because the customers and restaurants expressed some importance on taste differences. Health was the main reason consumers and grocery stores purchase organic and GMO-free food. Some restaurant owners and chefs wrote "health" in the fill-in section as a reason to buy organics, but the majority selected taste as the reason for choosing organics. This statistic is logical because restaurants rely heavily on taste to run successfully and create a loyal consumer base. Table 3 below displays responses from restaurants that chose to explain why they do not purchase organic and/or GMO-free food.

Table 3: Restaurant Survey- Reasons restaurants do NOT purchase organic/GMO-free food products

Price	53%
Convenience	34%
Availability	13%
Lack of knowledge	9%

The main reason restaurants do not purchase organic and GMO-free products was price and convenience. Many restaurant owners and chefs expressed their belief that organic and GMO-free products are only available on a small scale and the amount available is not always consistent, so they cannot rely on these products to run their business. Price was also one of the dominant reasons consumers do not buy organic and GMO-free food as expressed in an open response question on the consumer survey. Fourteen percent of the responses were price and 14% of the responses were availability.

Overall, some of the community is recognizing benefits of organic and GMO-free products, such as the health benefits, taste and shelf life, but some businesses and consumers are not buying these products because of high costs and limited availability. These results suggest opportunities for growth exist within the aquaponics industry because consumers and restaurants are expressing there are not enough providers of this type of produce.

A restaurant survey question asked if restaurants would consider using local, organic food products including fish, produce, both, or none. The resulting data helped determine restaurant interest in aquaponic food products; the results are displayed in Figure 13.

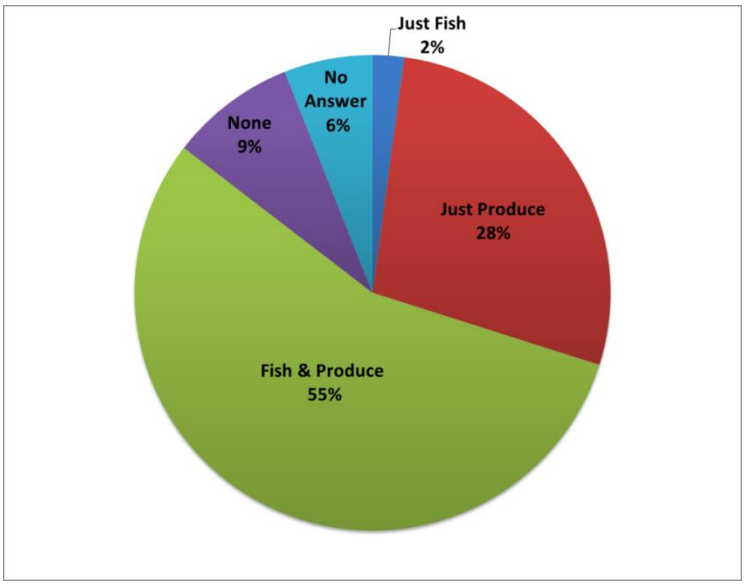

Figure 13: Restaurant Survey: Interest in purchasing organic fish and produce

The pie chart above shows that there is some interest in using local, organic products in the restaurant industry in Puerto Rico, therefore signifying a potential for growth in the aquaponics industry.

Two correlation tests helped us understand if consumers' knowledge of organic and GMO-free products affects their decisions to purchase them. A significant Pearson correlation ($p<0.001$) between knowledge of organic and purchasing organic is 0.399, which means generally those who know about organic are more likely to purchase organic. A significant Pearson correlation ($p <0.001$) between knowledge of GMO-free and purchasing GMO-free is very similar at 0.412 meaning that generally those who are familiar with GMOs are more likely to purchase GMO-free. These statistics support our statement that the market interest for products grown through aquaponics is somewhat dependent on the community's level of education about organic and GMO-free options. On the consumer survey, 72% of respondents indicated that they "agree" or "strongly agree" to reading labels on their food. This statistic shows that consumers are interested in knowing about the types of food they consume. Of those

who read food labels, 51% and 29% agreed or strongly agreed to buying organic and GMO-free food products, respectively. The data suggest more knowledge of organic and GMO-free products and reading food labels could increase purchasing of these products.

3.2.4 Research Question C: Where is the best market interest for products grown in aquaponic systems (organic and GMO-free)?

The popularity of different types of grocery stores was evaluated via the consumer survey. Consumers were asked where they purchase their groceries, and answers can be seen in Table 4. The total number of responses is greater than the sample size because respondents could select all answers that applied.

Table 4: Consumer Survey- Responses to the question "Where do you typically buy your groceries? (Check all that apply)"

Type of Store	Number of Responses
Wholesale	19
Supermarket	75
High-end/Specialty Store	27
Corner Store	22
Local Market	36

The table indicates that most consumers purchase their groceries in supermarkets.

Types of restaurants, “fast casual”, “casual”, and “fine dining”, were compared with the amount of organic, domestically grown, and GMO-free food they purchase to evaluate the

potential for aquaponic products in restaurants. One graph representing the use of organic food in different types of restaurants is shown in Figure 14.

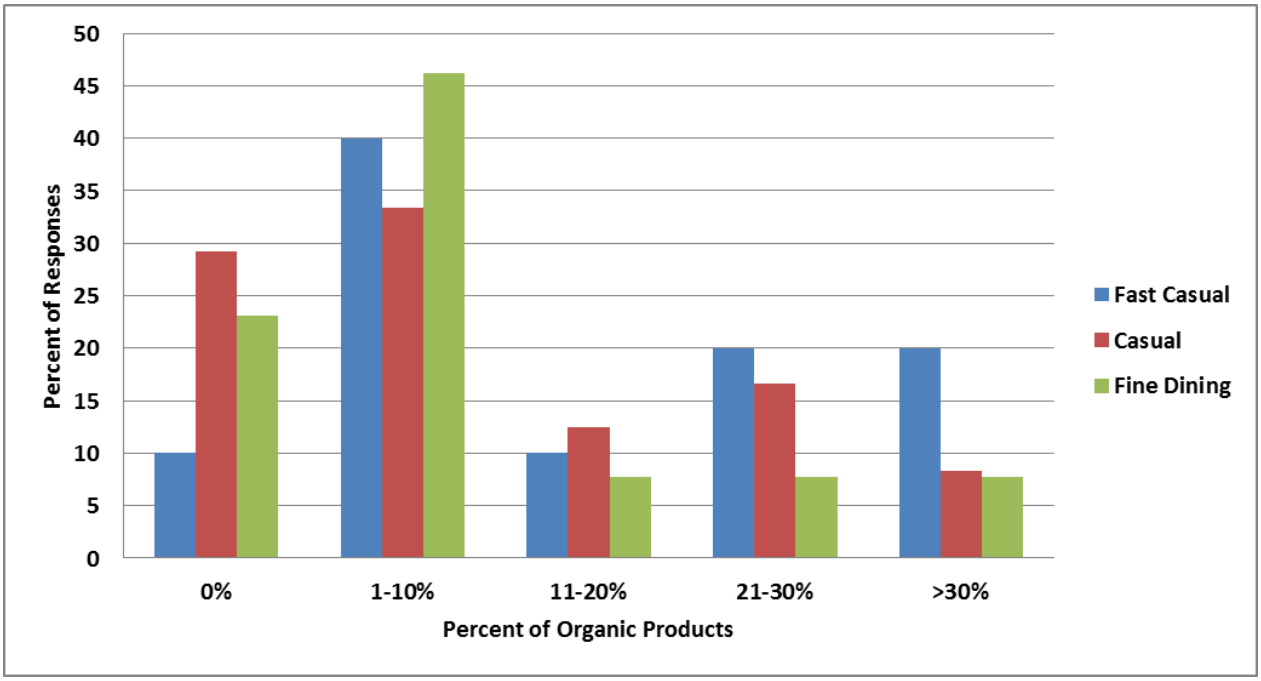

Figure 14: Restaurant Survey- Percent of organic products used in different types of restaurants

Visually, there is no apparent difference in buying patterns depending on the type of restaurant. Based on three ANOVA tests it is shown that organic, domestically grown and GMO-free products used by restaurants are not dependent on the type of restaurant ($F=0.992$, $p=0.379$; $F=0.848$, $p=0.435$; and $F=0.053$, $p=0.949$; respectively). We expected to find extreme differences between the types of restaurants and percentage of organic products. Instead we found that most fast casual, casual, and fine dining restaurants use 1-10% of organic products. In addition, ANOVA tests were performed to contrast results between restaurant locations (Old San Juan, Condado, and Isla Verde). These tests show that organic, domestically grown and GMO-free products used by restaurants are not dependent on location of restaurant ($F= 0.584$, $p= 0.449$; $F= 2.579$, $p= 0.088$; and $F= 0.147$, $p= 0.704$; respectively).

No conclusive statistics could be used to evaluate which type of grocery store or store location was the best market for organic and GMO-free products due to the small sample size. However, we observed that high-end grocery stores and specialty stores had a larger selection of organic options. The data showed no significant evidence that the type and location of restaurants and grocery stores affects the market for aquaponic products.

3.2.5 Research Question D: Are restaurants interested in a small-scale aquaponic system for their business?

Restaurants were asked if they would be interested in having a fully serviced small-scale aquaponic system in their restaurant. This system is a slightly different approach to the expansion of the aquaponics industry, as it could provide restaurants with their own supply of fresh produce and/or herbs. Their answers are displayed in Figure 15 below.

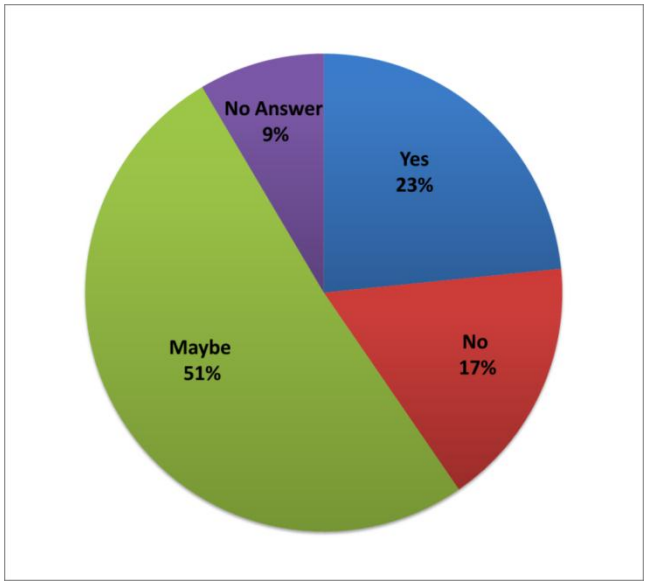

Figure 15: Restaurant Survey- Interest in a fully serviced small-scale aquaponic system

Over half of the restaurants surveyed indicated they might be interested in an aquaponic system. When asked why or why not, a majority of the restaurants expressed concern about the cost of implementing and maintaining the system and the amount of space needed. The high number of

"maybe" responses could also be due to a lack of knowledge about the technology and food produced by the system, particularly as a profitable business decision, as stated in an open response answer. Alternatively, many restaurants stated that they would be interested in a system because it would provide their customers with health benefits. Based on the results, we believe there is potential for growing the aquaponics industry in restaurants through this strategy. There was no significant difference between restaurant types when evaluating interest in a small-scale aquaponic system, shown in an ANOVA test ($F=1.995$, $p=0.149$). Those who were reportedly unsure about having a system would benefit from further information to understand the system and its effect on their business.

Overall, there is evidence of interest in aquaponic products in the Puerto Rican market. The community is more knowledgeable about organic products than GMO-free products. The data also show consumers' amount of knowledge about these products relates to their willingness to buy. Knowledge and interest in purchasing organic and GMO-free products are not dependent on age and ethnicity of consumers or location and type of restaurant and grocery store, so no specific market can be targeted based on these conditions.

4.0 Aquaponics Education

4.1 Aquaponics Education Methods

Agroponicos also focuses on aquaponics education for potential employees of the aquaponics industry and proprietors of aquaponics businesses. Our team assessed the effectiveness of a vocational workshop conducted at Caribe Fisheries in Lajas, Puerto Rico. This program was chosen because it was held during our time residing in Puerto Rico and was instructed by Pedro Casas Jr. of Agroponicos. Multiple steps were required to properly evaluate this existing program. To prepare for the evaluation of the workshop, we organized two interviews to gain general information about vocational programs. This background information gave us a better understanding of the elements of successful vocational programs and how to effectively evaluate them. We also interviewed the aquaponics instructor and created evaluation surveys. All interviews were conducted in person; one or two team members led the conversation while one team member took notes. For each interview, questions were prepared in advance to maintain structure and ensure the interview stayed on-task, tailoring each set of questions to the respective interviewee.

4.1.1 Preparation Interviews

Worcester Polytechnic Institute's Corporate and Professional Education (CPE) provides a variety of professional development workshops and technical programs. We contacted the CPE to schedule an interview with an experienced staff member knowledgeable in conducting and evaluating professional education programs, Rachel LeBlanc. The interview was held at WPI prior to arrival in Puerto Rico and lasted approximately forty-five minutes. The details of the interview are provided in Appendix H. The interview provided us with the components of an effective professional education program to refer to in the evaluation of the program at Caribe

Fisheries. The conversation also offered new ideas and standards for future evaluations and observations.

The second interview was conducted with Chelsea Wright, a student of the Patel College of Global Sustainability at the University of South Florida pursuing a master's degree in aquaponics and marketing. She recently conducted research with the Aquaponics Institute and has attended and evaluated educational programs. The interview, held at the Agroponicos site, lasted about an hour and fifteen minutes. A transcript of this interview is provided in Appendix I. An abundance of qualitative information was gained regarding her opinion on how vocational workshops should be conducted, the appropriate duration of different workshops, the most efficient number of attendees, what qualities make a successful workshop and how to appropriately evaluate these workshops.

4.1.2 Aquaponics Workshop Evaluation

An aquaponics education program that exists in Puerto Rico is a one-day vocational workshop at Caribe Fisheries, an aquaculture farm in Lajas, at a cost of about $80 per person. Typical attendance for the program is between ten and thirty-five people. This workshop is an introductory program designed to provide more information about aquaponic technology and aquaculture, as well as encourage the attendees to consider more in-depth training programs. We evaluated the program at Caribe Fisheries using an interview with an aquaponics workshop instructor and evaluation surveys.

4.1.2.1 Instructor Interview

Pedro Casas Jr. led the aquaponics portion of the workshop and the farm owner led the aquaculture portion. Three weeks before the scheduled workshop, we interviewed Casas and gained a better understanding of the instructor's learning objectives and goals for the program.

The interview helped identify the principal information and skills that workshop attendees should acquire, and his background and education in aquaponics. The semi-standardized interview questions obtained specific information but still allowed Casas to relay his feelings and personal opinions about the program. The transcript of this interview is provided in Appendix J. Information obtained through Casas' interview was used to revise our workshop evaluation surveys to better reflect the specific goals of the program. The instructor's insights set expectations for the workshops, acting as a guideline for the evaluation of the program, as well as identifying the target audience. The knowledge of the audience can vary by workshop, but the program is intended to provide introductory information.

In addition to the interview, two team members participated in a private information session with Pedro Casas Sr., Pedro Casas Jr., and Jorge Casas to understand the lecture content and technical aquaponic skills learned through the vocational workshop. Pedro Jr. presented his aquaponics lecture to the team members in English because the presentation is given in Spanish at the workshop.

3.1.2.2 Evaluation Surveys

Two team members attended the vocational workshop and evaluated the program using observations and surveys. The surveys were adapted from WPI's course evaluation form completed by each student at the end of every course, combined with suggestions from Rachel LeBlanc, Chelsea Wright, project advisors and sponsors. Two different surveys were used in the evaluation of the aquaponics workshop. One survey was designed for current attendees of the program and the other was designed as a follow up for those who attended a workshop previously.

The current attendee workshop evaluation survey focused on measuring the quality of the program, the effectiveness of the teaching methods used, and the attendees' intent to apply knowledge learned through the program. The survey also aimed to identify information about workshop participants to help tailor future programs to the specified audience. The survey was divided into four sections. Three sections contained questions on a five-point Likert scale: "strongly disagree" (1) to "strongly agree" (5), "not enough" (1) to "too much" (5), and "very poor" (1) to "very good" (5). The last section contained multiple choice and open response questions. These questions included demographic information, reasons for attending the program, and suggestions for possible improvements to the program. The length of the survey was kept to a minimum, to be completed in 10 to 15 minutes, to increase participation and ensure completion of all questions. The current attendee workshop evaluation survey is provided in Appendix K.

A total of ten surveys were distributed to the entire population of current workshop attendees. The survey was designed to provide quantifiable results allowing for a direct evaluation of the quality and effectiveness of the instructors and material. The data also helped identify the areas in need of improvement.

The past participant workshop evaluation survey was intended for distribution to past attendees of vocational workshops at Caribe Fisheries. This survey was similar to the current workshop evaluation survey but also addressed the practical application of knowledge and skills learned through the workshop to evaluate the effectiveness of the workshop over time. The survey is provided in Appendix L. The survey was entered into Qualtrics, a software program that allows participants to access the survey using a website link. The link contained an option to complete the survey in English or Spanish and was tested by all team members to ensure proper functioning. A brief letter was created that explained the project and the purpose of the survey

and included the survey link. To avoid confidentiality issues, Pedro Casas Jr. intended to distribute the letter to previous workshop attendees via email, however time constraints prevented survey distribution. The survey in both hardcopy and online form were given to Agroponicos for future use. Overall, the data obtained through interviews and the evaluation survey were analyzed to determine if the workshop met the criteria of a successful instructional program and to identify where improvements can be made. Graphs were used to analyze these data.

4.2 Aquaponics Education Results

4.2.1 Research Question E: Who is the audience? Why are they taking the workshop?

Our team collected and analyzed the surveys completed by the ten workshop attendees from the workshop at Caribe Fisheries in Lajas. Demographic and general information for these subjects are displayed in Figure 16.

Ethnicity	
Caucasian	1
Hispanic	9
Asian	0
African American	0
Other	0

How attendees learned about the program	
Facebook	0
Online	3
Word Of Mouth	4
Other	2
No Response	1

Age	
18-25	1
26-35	2
36-45	6
46-55	0
56-65	0
66+	1

Gender	
Male	9
Female	1

Figure 16: Workshop Survey- Demographic information of workshop participants

An important aspect of a successful workshop is to know the audience, so we evaluated why participants chose to attend the workshop. An open response survey question reflected that the majority of the participants attended the workshop to gain more information about aquaponics. This information indicated that the audience for this specific workshop had prior interest and knowledge about aquaponics and aspired to learn more. Based on team observations, attendees had vast knowledge about organic and GMO-free food products, shown by the discussion with all attendees and instructors about these types of food that occurred when the workshop had concluded. This discussion included information about attendees' reasons for choosing to buy mostly organic and GMO-free food products. Audiences of other workshops could not be evaluated and may vary, but this specific audience was interested in aquaponic technology and knowledgeable about organic and GMO-free food products. Full results of the workshop evaluation survey are shown in Appendix N.

4.2.2 Research Question F: Are the instructor's goals lining up with the attendees' goals?

The aquaponics instructor of this workshop, Pedro Casas Jr., expressed his main objectives during the instructor interview, which included: educating the audience about the importance of water quality, inspiring attendees to become more curious about aquaponics, and allowing attendees to get a basic introduction to aquaponics. When describing the workshop, Casas called it a "teaser" program. Based on the audience, we deduced that Casas' first objective was appropriate because as stated previously, the attendees wanted to learn more about aquaponics, and water quality is a specific area in which the attendees can gain further information beyond their general understanding. From observations, the last two objectives were not as relevant to this workshop group because the attendees are already interested and generally knowledgeable about the system. Many attendees already had aquaponic systems. These objectives would be more relevant for beginner students.

To evaluate the consistency between the information presented and the attendees' desired learning experience, overall expectations were addressed. Workshop participants were asked to rate the statement "This program met most of my expectations" on a five-point Likert scale from "strongly disagree" (1) to "strongly agree" (5) and results are displayed in Figure 17.

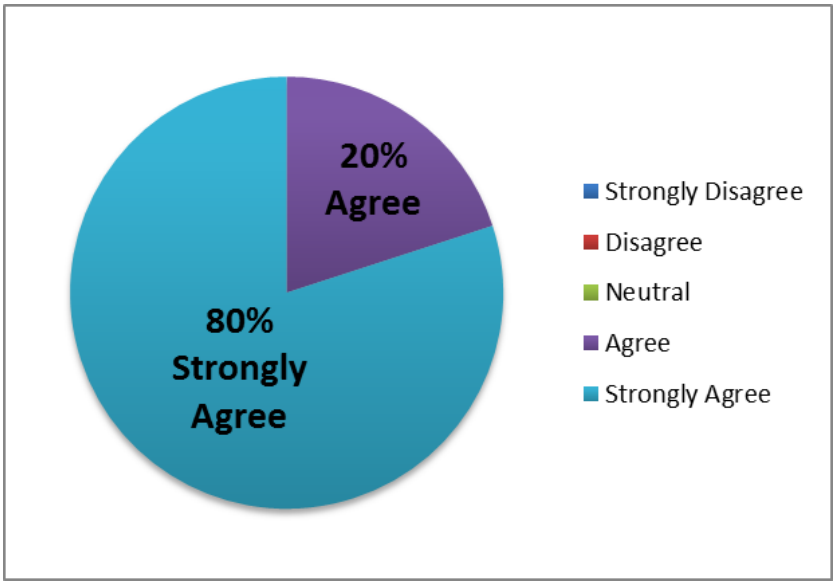

Figure 17: Workshop Survey- Expectations of workshop attendees

Based on the attendees' responses on the survey, the information presented at this workshop was well tailored to the audience and their level of education. We learned from informal feedback that the workshop content was well received; multiple attendees responded to an open response question regarding likes and dislikes that they were satisfied with the provided information. The only negative comment was about the location of the program, due to travel inconvenience.

We also analyzed the attendees' opinions on the material presented to further identify how the program compared to their expectations shown in Figure 18 below.

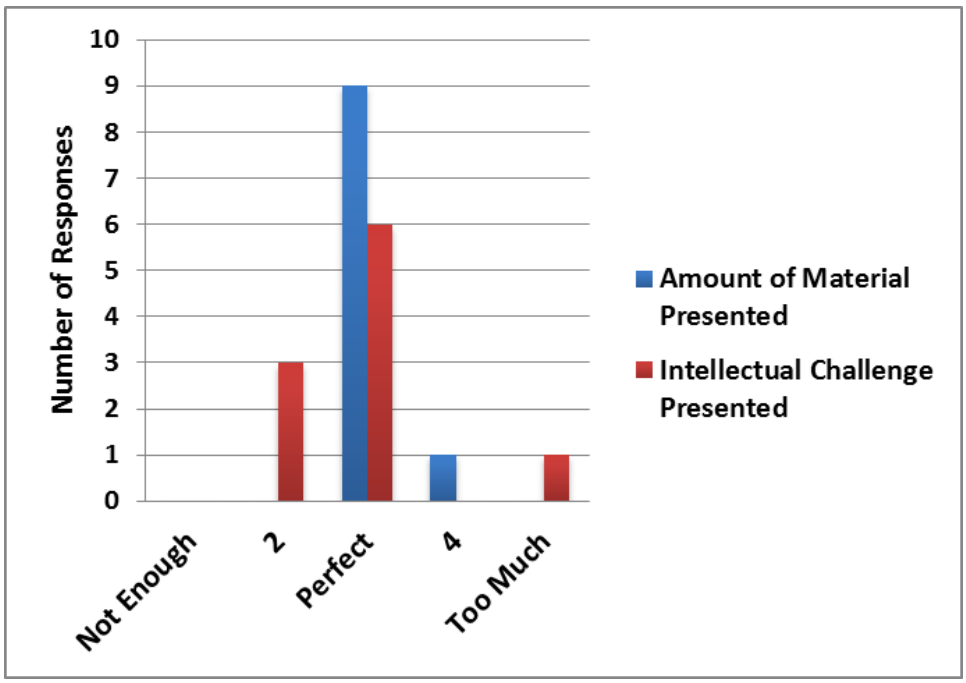

Figure 18: Workshop Survey- Amount of material presented vs. intellectual challenge presented

In addition, the amount of time spent on lecturing and hands-on learning was compared to further assess the attendees' satisfaction with the program. The aquaponics instructor spent 1 hour and 10 minutes lecturing and 30 minutes studying the system with the students. Additional time was reserved for discussion and questions. On the evaluation survey, the attendees were asked on a five-point Likert scale from "not enough" (1) to "too much" (5) how they felt about the length of time spent on lecture vs. on hands-on learning. Results are shown in Figure 19.

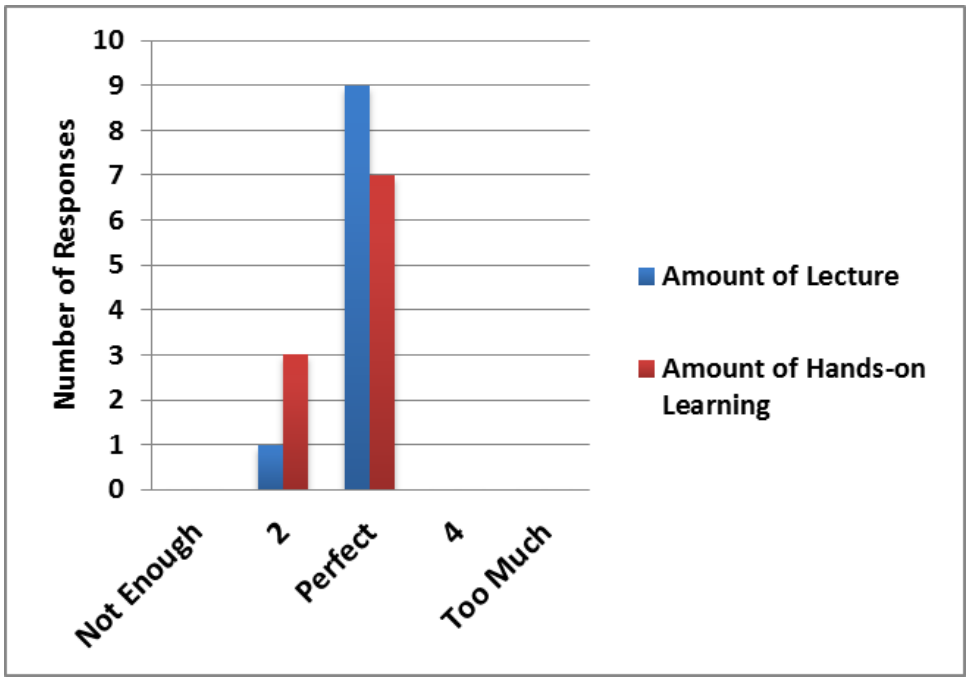

Figure 19: Workshop Survey- Amount of lecture vs. amount of hands-on learning

The majority of attendees believed the amount of lecture time and hands-on time was appropriate. An attendee commented on the survey that he or she particularly liked separating into groups to split the time, half spent on aquaculture and half spent on aquaponics. Overall, the attendees were satisfied with the allocation of time at the workshop.

4.2.3 Research Question G: Are the instructors stimulating interest in their workshop attendees? Are their teaching styles effective?

A large component of an effective vocational program is instructors who engage their audience, according to both Rachel LeBlanc and Chelsea Wright. We evaluated how well the instructors were inspiring and exciting the audience through a five-point Likert scale question from “very poor” (1) to “very good” (5). Responses are displayed in Figure 20.

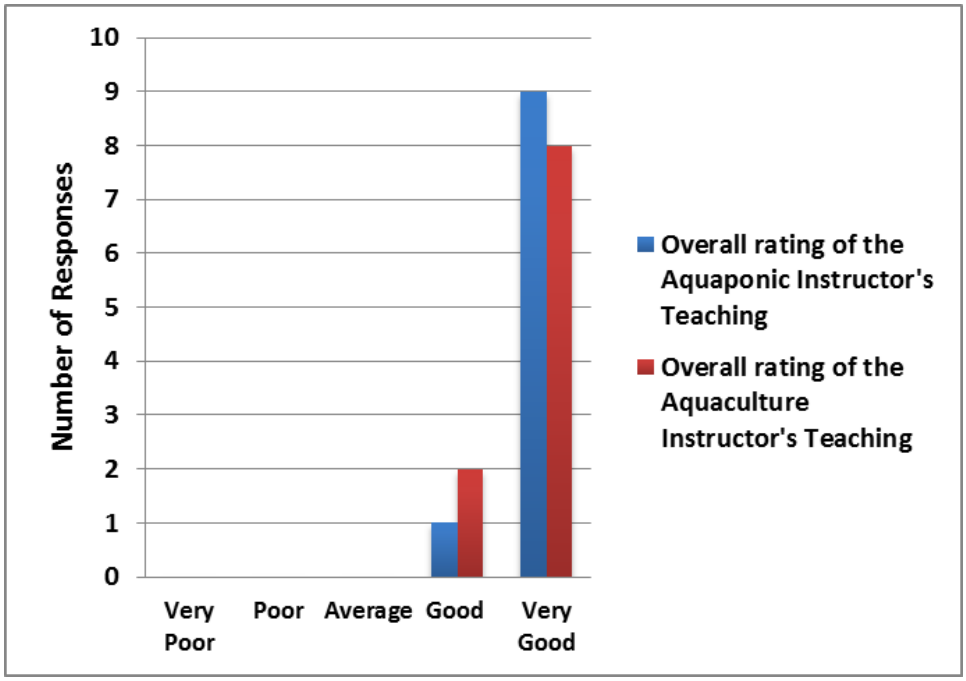

Figure 20: Workshop Survey- Overall ratings of aquaponics and aquaculture instructors

For this project, we focused primarily on the educational component of the workshop regarding aquaponics, but both the aquaponics and aquaculture instructors' ratings are provided in the figure. Both instructors had very high ratings as the majority of the attendees rated the instructors "very good." Neither instructor received a rating lower than "good" which indicated the high satisfaction rate of the attendees. Additional comments on the surveys supported the statistical data. One attendee stated, "The personnel is well informed and experienced…" Another attendee said, "The teachers' energy and availability is (sic) amazing!" This connection between the instructors and the audience is a key component in effective workshops (LeBlanc, 2013).

4.2.4 Research Question H: How do the workshops create potential opportunities to grow the aquaponics industry?

Education in aquaponics was assessed to understand its relation to the larger goal: to expand the aquaponics industry on the island. In order to evaluate how education can make

strides toward this goal, we asked the attendees if they currently have or plan to build an aquaponic system. The responses can be seen in Figure 21.

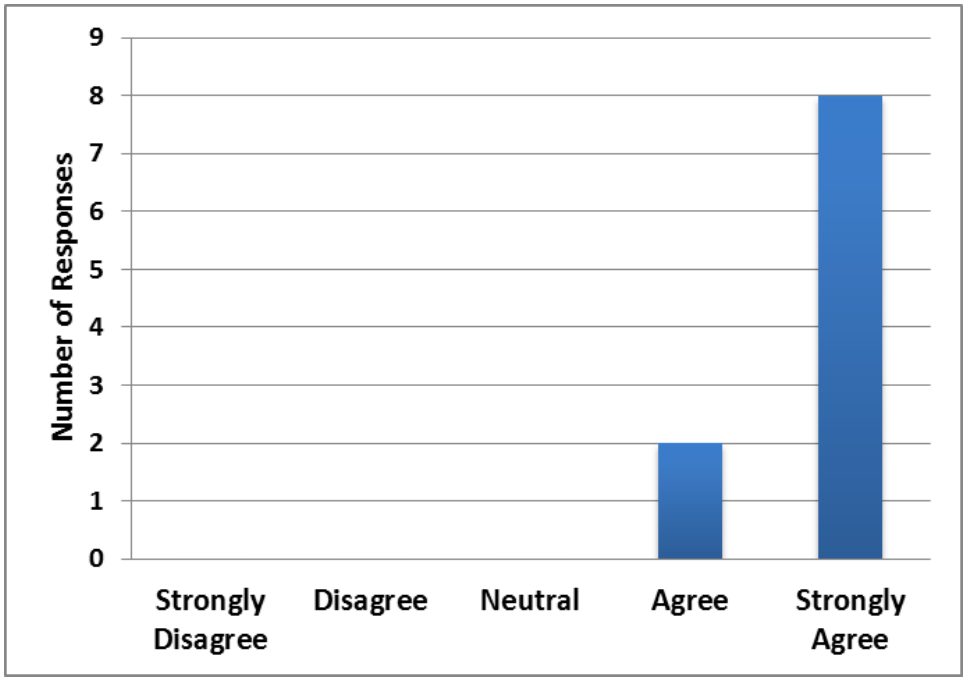

Figure 21: Workshop Survey- Attendees currently have or plan to build an aquaponic system

Each workshop participant agreed or strongly agreed that they have or plan to build an aquaponics system. An even more valuable measure of the workshop's effectiveness on the overall expansion of aquaponics was assessed by evaluating how attendees intend to apply their newly attained information. See Figure 22.

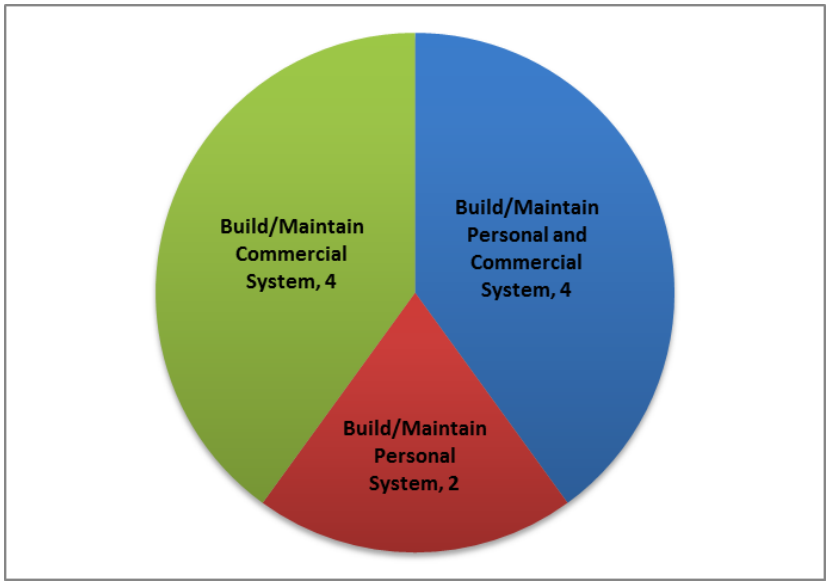

Figure 22: Workshop Survey- Number of subjects agreeing with these mutually exclusive statements

These data indicate there will be at least ten personal or commercial systems on the island from the attendees of this workshop alone.

Finally, to expand the education of aquaponics beyond the small workshop audience, attendees were asked if they would recommend this workshop to others using a five-point Likert scale from “strongly disagree” (1) to “strongly agree” (5). Responses can be seen in Figure 23.

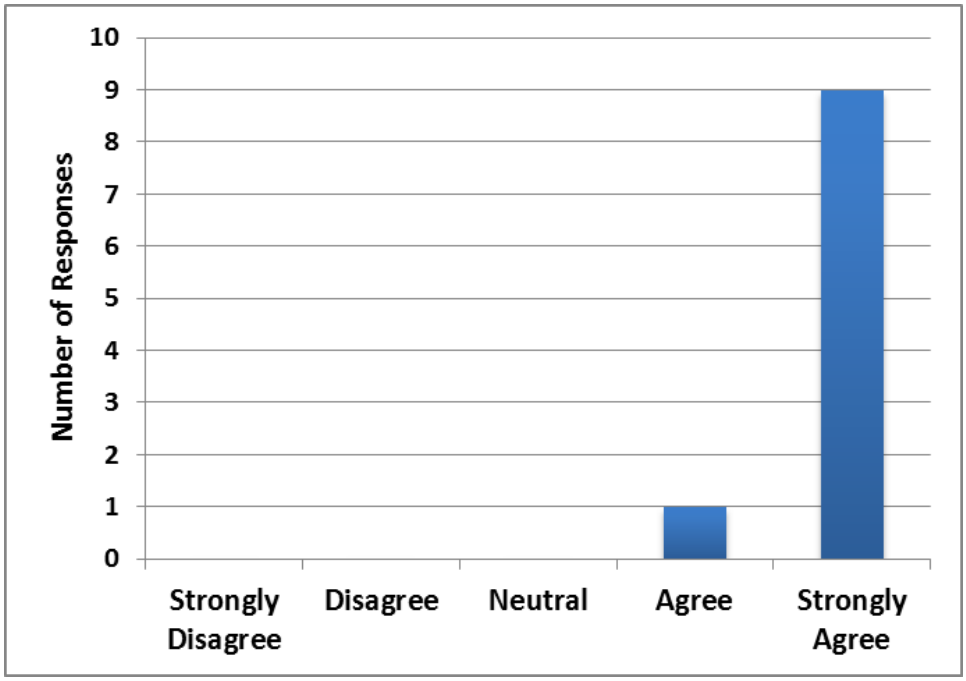

Figure 23: Workshop Survey- Attendees' ratings of the statement "I would recommend this program to others"

The program was highly recommended by all workshop participants. Past participant surveys could not be administered, limiting the amount of data that could be collected and analyzed.

In general, the workshop attendees were knowledgeable about aquaponic systems and the instructors appropriately addressed the knowledge level of the audience. Attendees were satisfied with their experience and planned to apply their newly obtained knowledge by creating personal and commercial aquaponic systems, indicating growth of the aquaponics industry. Despite the small sample size, the results indicate an opportunity for educational programs to improve and therefore expand the industry.

5.0 Limitations

There are many common limitations with surveying as a method of data collection, and many apply to the surveys distributed for this project. Biases associated with surveying include response bias, acquiescence bias, and non-response bias. In many cases, respondents will not answer certain questions honestly and instead answer based on what they believe will please the questioner, a type of response bias (Assael & Keon, 1982). Some survey participants may have been under the impression that the group members were supportive of organic and GMO-free products. False responses can also be attributed to a lack of knowledge about the question topics and misunderstandings due to question wording and translation issues. An example of response bias occurred with the workshop evaluation surveys. Many of the attendees heard about the workshop through word of mouth, particularly through aquaponics instructor Pedro Casas Jr., and may have been hesitant to give harsh reviews. Non-responses are also a concern with some questions on surveys; blank answers could be due to a lack of knowledge or unwillingness to answer the question. Another limitation with surveying is acquiescence bias where respondents tend to agree with all questions regardless of the statement (Assael & Keon, 1982). Our team's consumer survey contained a five-point Likert scale of "strongly disagree" (1) to "strongly agree" (5), making this type of bias especially prevalent. To combat this bias, open response questions were included.

Another bias associated with this project is common method bias; when using primarily one research method, there is a possibility of misrepresented or skewed results. The main method used for all data collection was surveying. We conducted interviews to restrict the impact of this limitation.

Finally, the majority of the research was conducted in a small area of San Juan for practical reasons, thus limiting our ability to draw conclusions about other areas of Puerto Rico. We were also challenged by time and travel constraints, which limited the amount and variety of data collected. To overcome these challenges, highly populated areas were visited for efficient data collection and travel routes were planned to utilize time effectively.

To organize all plans associated with the project and overcome the discussed time and travel constraints, an active calendar was updated throughout our time in Puerto Rico. The calendar was used to plan visits to the Agroponicos farm, fieldwork, and preparatory work. We planned weekly trips to the farm to learn about the aquaponic system, keep in contact with the project sponsors, and ensure consistency with goals. A Gantt chart organizing overall goals for the project is provided in Appendix M. By using this chart, we organized the specific tasks that needed to be completed and the time allotted for completion.

6.0 Recommendations

The analyzed data were used to generate several recommendations for Agroponicos. Our suggestions encompass ways to improve the market interest and the community's knowledge about organic and GMO-free products. We also provided recommendations to improve aquaponics education based on our assessment of the workshop. Our recommendations based on the assessment of market interest include the following:

1. Emphasize organic and GMO-free on product labels and advertisements.

Our results show that 72% of surveyed consumers typically read their food labels. Agroponicos could continue to emphasize the organic and GMO-free classifications through their marketing with the hopes of raising awareness. Currently 41% of consumers purchase organic products frequently and 25% purchase GMO-free products but there is the possibility of increasing consumer purchasing of these types of food. Consumers' knowledge of organic and GMO-free foods affects their willingness to purchase these types of products, shown by significant Pearson correlations ($R=0.399$, $p<0.001$ and $R=0.412$, $p<0.001$ respectively). These data led us to recommend that Agroponicos provide further education to the Puerto Rican community about organic and GMO-free food products.

2. Educate the community about organic and GMO-free foods via informational pamphlets.

Informational brochures explaining the benefits of consuming organic and GMO-free food, particularly aquaponic products, could be created for distribution to consumers at farmers markets and other publicity events, as well as restaurant and grocery store managers. Seventy-six percent of all surveyed consumers reported that they buy organic and GMO-free because of health benefits, so emphasizing health in the brochures could encourage the community to purchase these products. These pamphlets can also emphasize shelf life and value as potential

benefits of organic and GMO-free products; results show that none of the surveyed restaurants buy organic and GMO-free products for these reasons and they may not understand these benefits. Providing instructions on where to purchase these products and how to read food labels and PLU (price look-up) codes for produce would also be beneficial because many consumers read food labels, and education will ensure that labels are read properly.

Restaurants

Education about organic and GMO-free food products for restaurant managers, purchasing managers, and chefs through marketing and promotion could help create a larger market for aquaponic products in the restaurant industry. Twenty-six percent of restaurants did not respond to the question about purchasing GMO-free products and many surveyed managers and chefs asked about genetically modified organisms, indicating a lack of knowledge. However, a significant 59% of restaurants would consider buying aquaponic products. By educating restaurant owners via the informational pamphlet about products grown through aquaponic systems, restaurants may become more willing to consider purchasing these products. Promotional materials for Agroponicos and samples of their products could help convince restaurants to alter their purchasing choices.

Grocery Stores

Our results show that 41% of consumers purchase organic or GMO-free food products because of the taste. As an attempt for more consumers to recognize the fresher taste and purchase these products, we recommend Agroponicos offer samples in the stores. Agroponicos can make arrangements with the stores to set up a table during a few of their busy hours with fresh samples from the farm, along with the informational pamphlets for more information.

3. <u>Educate about organic and GMO-free products at schools.</u>

Another suggestion to educate the community about these types of food products is to organize consistent visits to schools of all levels with appropriate programs for each level. Knowledge about organic and GMO-free food products did not differ by age and ethnicity based on ANOVA tests. However, a t-test comparing Puerto Rican residents and non-Puerto Rican residents' showed that local residents have less knowledge about these food classifications than non-residents. Based on this demographic analysis, visiting Puerto Rican residents at local schools can target the less-educated population. Students are the future consumers of the market who will be driving the demand for aquaponic products for many generations. By providing education about food consumption to school age students, the younger generation can potentially become educated consumers, improving the market for aquaponic products in the future. According to Rachel LeBlanc, the average attention span for an adult is twenty to thirty minutes, in children it is usually less, and any program requires interactive aspects to maintain the focus of the audience. To keep students engaged, product samples and recipes using aquaponic food products could be distributed. For high school level students, a presentation about aquaponic technology and the opportunity for the trade as a career path may encourage more individuals to become involved with the aquaponics industry. Interested students could be directed to vocational aquaponics workshops.

4. <u>Place an emphasis on marketing products as locally grown.</u>

Data from this project indicate consumers in Puerto Rico are less knowledgeable about GMO-free options than organic, as 70% of consumers have a basic knowledge of organic and 51% have a basic knowledge of GMOs. Some importance has been placed on buying locally. The data indicate that many restaurants, grocery stores, and general consumers rely on non-organic and GM food products. If the community's awareness does not improve, Agroponicos

should alter their marketing approach to accommodate the common knowledge of the community. Rather than emphasizing education about GMO-free products, Agroponicos could market their products as locally grown and place a greater emphasis on "local" in their product labels. This change in marketing tactics could help Agroponicos maintain their current clientele and expand their consumer base. This suggestion from Chef Wilo Benet can help offset the apparent lack of knowledge in the community about organic and GMO-free food.

A low percentage of consumers are aware of the benefits of organic and GMO-free; only 0%, 28%, and 15% of consumers believe benefits are quality, shelf life and value, respectively. Focusing on the social importance of supporting local farmers to improve Puerto Rico's economy through these food products can help counteract the low awareness of other benefits.

5. Administer surveys to the general public to discover why consumers who often purchase organic and GMO-free food decided to begin purchasing this way.

Agroponicos could benefit from additional research work beyond the scope of our results. It would be helpful for Agroponicos to know how the consumers that currently buy mostly organic and GMO-free products decided to make this purchasing choice. With this information, Agroponicos can adjust their marketing and education as necessary. The company can stress the benefits of products grown through aquaponics, particularly highlighting the importance of farming without genetic modifications. This research can be achieved by targeting informed consumers at workshops, who are knowledgeable about aquaponic food products and the benefits of consuming organic and non-modified foods. The data collected through these surveys could be analyzed to determine how to educate other consumers about these food options. The data could also provide marketing ideas to encourage consumers to replace their non-organic, genetically modified products with organic, GMO-free products.

6. Focus distribution on supermarkets.

Seventy-one percent of consumers purchase their food at supermarkets. By distributing to supermarkets, the products may reach a large consumer base.

7. Present business models to restaurants for growing their own produce through aquaponic systems.

Results from restaurant surveying indicated a fairly strong interest in using small-scale aquaponic systems to grow produce for their business; twenty-three percent of restaurants said they are interested, and 51% said they might be, often depending on space and other logistics. As an option, small-scale aquaponic systems could be installed in restaurants, on the roof or other available areas, to self-supply produce and fish. As a second option suggested by Wilo Benet, a hydroponic bed or portion of a bed at Agroponicos' farm or future aquaponic farms could be designated for a specific restaurant's supply only, promising a supplier and customer partnership. For either option, the business plan would need to include costs for setup and maintenance of the system, the space required, and any other terms that would apply to the arrangement.

8. Choose aquaponics products based on demand.

According to grocery stores, lettuce and tomatoes are the products with highest sales out of all the produce that can be grown through aquaponics. Since sales are an indication of demand, we suggest Agroponicos consider growing these two items to supply the market demand.

9. Utilize the internet for marketing.

To utilize online resources, Agroponicos could create a website that includes information about the company, the products they produce, and the farming system they use. It should also describe a mission statement relating to their goals and morals. The website could also contain news about the growing aquaponics industry and its importance on the island. Information about

upcoming vocational aquaponics workshops in Puerto Rico and a link to register online, frequently asked questions, and a photo gallery of pictures from Agroponicos' farm could also be included on the website. The website could be another tool for increasing knowledge about organic and GMO-free food products to help increase purchasing tendencies.

Our recommendations based on the assessment of the educational workshop include the following:

1. Utilize Facebook to advertise for aquaponics workshops.

Agroponicos could improve the use of their Facebook page, which is being underutilized because no respondents heard about the evaluated workshop at Caribe Fisheries through Facebook. By posting invitations to upcoming workshops, the link to the company website and updates about the farm and the crops produced, the company can use Facebook to its full potential. Facebook is a valuable resource because it is free to use and social media is an increasingly popular form of communication. Agroponicos should invite friends and family to "like" their Facebook page to increase the amount of people that see updates and statuses posted by the company to help spread knowledge and expand the aquaponics community. Increased advertising of workshops could potentially lead to increased attendance at vocational aquaponics workshops.

2. Hold workshops at other locations.

Agroponicos could utilize their own successful system as a model for others by holding vocational aquaponics workshops at their farm. Located in Puerto Rico's capital, San Juan, the farm is easily accessible. A suggestion from Rachel LeBlanc from WPI's Corporate and Professional Education was to label all components of the aquaponic system using signs as a

visual aid for workshop participants to potentially improve the learning process, and this could be done at Agroponicos. Potential new aquaponic sites in Caguas and Juncos, planned to be built in the future, could also provide opportunities for workshop locations. Utilizing multiple locations could make attending a workshop more convenient compared to only one site option. This expansion could increase the number of workshop attendees, therefore increasing the aquaponics community and industry.

3. Improve workshop experiences by tailoring to the audience and using evaluation surveys.

Educational programs are often most effective when the material presented is suited to the audience according to Rachel LeBlanc and Chelsea Wright. We recommend that a simple questionnaire be administered to registered workshop participants one week prior to the workshop via email. This questionnaire could contain questions to help identify the education and experience level of the workshop participants. With this information, instructors can adjust their lesson plans to better suit the audience, maximizing the effectiveness of the program. Programs can be tailored based on attendees' knowledge and experience with aquaponics and whether they are interested in personal or commercial aquaponic systems. For mixed audiences, groups at the program can be strategically divided according to their level of knowledge and experience. An example questionnaire is shown in Appendix O.

By distributing our team's evaluation survey after every workshop, Agroponicos and other workshop instructors can look at the patterns in responses to identify areas in need of improvement and aspects of the program that are going well and should be continued. Contact information of all workshop attendees could be collected to administer evaluation surveys to participants of past workshops. These survey results will allow for a more complete evaluation of the workshops and target people with particular interest in attending additional aquaponics

programs. According to LeBlanc, encouraging participants to attend follow-up programs increases success rates of the programs and helps individuals improve their skills.

All of the surveyed workshop participants agreed they either have an aquaponic system or plan to build one. In addition to follow-up surveys, we recommend Agroponicos offer to mentor these workshop attendees through the process of running their system. This mentor program could entail personalized visits to their system when requested and monthly check-ups. Understanding the areas in which the attendees are facing the most challenges could help Agroponicos alter their workshops to cover these topics.

Our team concludes there is a strong potential for the aquaponics industry to expand across Puerto Rico. There are multiple avenues for Agroponicos to take towards their goal of expansion. By focusing on improving their marketing and education, the awareness and interest of this technology and its products could greatly increase.

There are possible challenges that Agroponicos may encounter with these recommendations. Expansion of the market interest for aquaponic products will always be dependent on the price of the products. Consumers will not buy aquaponic products if they cannot afford them, regardless of education about these products. In addition, future aquaponics companies will create more competition with Agroponicos and could potentially hurt their own successful sales. Although Agroponicos' goals are not only to improve their own company, but also the aquaponics industry as a whole, increased competition and supply could greatly affect the market and balance the hopefully increasing demand.

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Appendices

A. Consumer Survey

		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1.	I have a basic knowledge of organic versus non-organic food options.	☐	☐	☐	☐	☐
2.	I prefer organic food options over non-organic options.	☐	☐	☐	☐	☐
3.	I buy organic food frequently.	☐	☐	☐	☐	☐
4.	I would be willing to pay up to 30% more for an organic food product.	☐	☐	☐	☐	☐
5.	I do not buy organic food products due to higher prices.	☐	☐	☐	☐	☐
6.	I have a basic knowledge of Genetically Modified Organisms (GMO).	☐	☐	☐	☐	☐
7.	I buy GMO-Free products frequently.	☐	☐	☐	☐	☐
8.	I typically read labels on my food.	☐	☐	☐	☐	☐
9.	I am familiar with aquaponics.	☐	☐	☐	☐	☐

10. I believe the benefits of organic/GMO-free food products are: (Check all that apply)

Taste ☐ Shelf Life ☐ Health Benefits ☐ Value ☐ Availability ☐ None ☐
Other: _____

11. Where do you typically buy your groceries? (Check all that apply)

Wholesale Store ☐ Supermarket ☐ Specialty Store/High-end Grocery Store ☐ Corner Store ☐
Local Market/Farmers Market ☐ Other: _____

12. Please explain why you do or do not purchase organic/GMO-Free food products:

Ethnicity/ Race

White/Caucasian ☐ Hispanic/Latin ☐ Asian/Pacific Islander ☐ Black/African-American ☐

Other: _____

Permanent Residence

Puerto Rico ☐ United States ☐ Other ☐

Age

18-25 ☐ 26-35 ☐ 36-45☐ 46-55 ☐ 56-65 ☐ 66+ ☐

B. Restaurant Survey

Please answer the following questions by checking the appropriate box.

		0%	1-10%	11-20%	21-30%	>30%
1.	What percentage of the food you purchase is organic?	☐	☐	☐	☐	☐
2.	What percentage of the food you purchase is grown domestically?	☐	☐	☐	☐	☐
3.	What percentage of the food you purchase is GMO-free?	☐	☐	☐	☐	☐

		Taste	Price	Convenience	Other (Please Explain)
4.	What is the main reason you do or do not purchase organic products?	☐	☐	☐	
5.	What is the main reason you do or do not purchase GMO products?	☐	☐	☐	

6. Where do you typically buy your produce? (Check all that apply)

Farm ☐ Distributors ☐ Local Market ☐ Other:_____

7. Would you consider using the following local, organic products in your restaurant?

Just Fish ☐ Just Produce ☐ Fish and Produce ☐ None ☐

8. Based on requests from customers, how important are organic/GMO free choices to them?

Not Important ☐ Somewhat Important ☐ Very Important ☐

9. Are you interested in having a fully serviced, small-scale aquaponic (combination of hydroponics and aquaculture) system in your restaurant?

Yes ☐ No ☐ Maybe ☐

Why or Why Not? (Please Explain):_____

C. Interview with Wilo Benet

Date: Wednesday April 3, 2013
Interviewer: Paige Westlake
Secretary: Katherine Newell

The interview began with introductions and a general overview of the project. Responses have been paraphrased into key points.

Wilo Benet: "Puerto Rico is so hungry for sustainable agriculture"

- Some Big hurdles:
    - Need mentality to want to pursue sustainability
    - Puerto Rico is not aware of what is going on with the agriculture industry or what they are consuming, would rather go to supermarket (convenience)
    - Many people on welfare
    - "Lazy" about farming- hard work
        - Less of an appreciation for hard labor
    - Most businesses work on credit (everyday way of doing business)- running a successful business is more important
    - Surrounded by water, yet no local fish
        - Not enough supply, not enough consistency
        - Consistency specifically important for restaurant business
    - Really is a "terrible situation," becomes costly to import vegetables from the United States
    - Need high quality AND consistency- no reliable industry in PR for that

Paige Westlake: Where do you purchase food for the restaurant?

Benet: Purchase most produce from a distributor, Chef's Garden in Ohio

- Puerto Ricans are a "special breed of people"
    - Will pay more for food in other places, won't pay more in PR
    - Do not litter in other places, but litter in PR
- Whole Foods: great store but none in PR, too costly to try and implement and operate
- La Hacienda: used to be a butcher shop, turned into a specialty store
- New line of work: packaging fresh foods with no preservatives
- Puerto Rico has such rich soil- that is not necessarily a challenge

Westlake: Have you heard of aquaponics?

Benet:

- Knowledgeable with aquaponics
    - Business models: provide jobs, improve local economy
    - Most business models need a facilitating partner: eliminate lack of interest in business for farmers
    - There needs to be a system created for successful agriculture businesses
- Farming has to come first!
- Other challenges with aquaponics:
    - Tilapia: not a good fish, not for high end
    - Needs variety
- "One stop shop" for restaurant purchasing would be great
- Have lots of experience, many restaurants and many employees
- In restaurant business, uniformity is so important
    - Produce and fish
    - Ex. of good consistency and its success: Big Mac
- Better eating habits and higher standards of food prep requires education
- Less is more vs. more is more
    - "more for your buck"
- Organic: health benefits/advantages yet to be proved
- Better taste provides a better selling point than "better for you" in most cases
    - Ex. Fatty foods taste good
- Higher end stores like Whole Foods requires more affluent area/clientele
- For most people, consumption of organic foods is mind over matter
    - True of most situations in life
- Puerto Ricans as consumers: unique elements
    - More cars per square mile than anywhere else on the planet
    - Plaza Las Americas' sales per square mile has rivaled that of Mall of America
    - According to the census, PR is under Mississippi for income/capita
        - Underground economy
    - Indicates that there is a strong **social importance**
    - **Behavioral- need to "strike a chord" or "make it cool"**
- Not currently using aquaponic products, haven't used them in the past (unless unaware)
- All produce comes from restaurant suppliers
- Puerto Ricans generally are against vegetables- like starch
- PR pineapple is phenomenal, but most go to production of juice
    - Get pineapple elsewhere, sweeter, better quality
- 50% of the market is tourists

- TRY to use local, but not happening
- Small restaurants have the capability to use local products from markets, "lots of love, but not lots of money"
    - Become your own slave

Westlake: One of the ideas Agroponicos is investigating is small-scale aquaponic systems for restaurants. Is that something you would be interested in?

Benet:

- Yes! as a side project
    - Have to stick to what you know
    - Not feasible for smaller places
    - Another idea: on a large aquaponic farm, one "lot" or bed becomes a specific restaurant's "lot"
    - Would give the system a shot
    - LOCAL- so important

Westlake: What are your opinions on GMOs?

Benet:

- GMO-free: has a greater impact in people's bodies than they know
    - United States is the only country that does not require labels
        - Comes back to education
        - Hard to educate about, difficult concept to grasp
    - Bad for consumer, health-wise

Westlake: Have you noticed any consumer trends in your restaurant?

Benet:

- Growing number of vegetarians
    - Indians/Hindus are traveling to PR, intellectuals and educated people, mostly vegetarians
        - Not only Indians, seeing an overall rise
        - At Pikayo, menu says "vegetarians please inquire"
- Gluten free trend
- Many special requests from customers
    - Some organic requests: use some organic materials at Pikayo but not a fully certified organic menu
    - Some rare requests, customer service issues
- Great possibility for aquaponics in Puerto Rico

- Letting people know it's LOCAL (lack of education)
    - Educate further on produce company websites
    - Positive effect for society
- People want to keep the island small
- Unused land in PR
- Market for local people without the technical details

Westlake: Have you done any promotional work about agriculture in Puerto Rico, and could you tell us about it?

Benet:

- Written many books and articles
    - Not certain, but some probably touched upon local sources of food and the agriculture industry in PR (too many to remember exactly which ones)

D. Grocery Store Survey

Please answer the statement by marking the appropriate box.

		0%	1-10%	11-20%	21-30%	>30%	I do not know
1.	What percentage of the produce you purchase is from local farms?	☐	☐	☐	☐	☐	☐
2.	What percentage of the produce you purchase is from distributors?	☐	☐	☐	☐	☐	☐
3.	What percent of foods sold in your store are organic?	☐	☐	☐	☐	☐	☐
4.	What percent of foods sold in your store are free of genetically modified organisms (GMO-Free)?	☐	☐	☐	☐	☐	☐
5.	What percent of customers inquire about organic or GMO-Free products?	☐	☐	☐	☐	☐	☐

6. I believe the benefits of organic/GMO-Free products are: (Check all that apply)

Taste ☐ Shelf Life ☐ Health Benefits ☐ Value ☐ Availability ☐ None ☐
Other: _____

7. Do you have customers who primarily purchase organic products?

Yes ☐ No ☐ Unable to Determine ☐

8. What organic and/or GMO-Free food products do you sell, if any? (Mark all that apply)

Vegetables ☐ Fruits ☐ Herbs & Spices ☐ Unsure ☐ Other: _____

9. Do you sell organic farm-raised fish?

Yes ☐ No ☐ Unsure ☐

10. Which food product is of highest demand in your store? (Mark one choice only)

Vegetables ☐ Fruits ☐ Herbs & Spices ☐ Fish ☐ Other: _____

11. Please circle the top three produce with the highest sales in your store.

Asparagus	Basil	Bay Leaves	Bell Peppers	Cabbage
Cauliflower	Cilantro	Cucumber	Lettuce	Mint
Mustard	Onions	Parsley	Sage	Tomatoes

12. Do you have a section in your store devoted to organic products?

Yes ☐ No ☐

Why or why not? (Please explain)

E. Consumer Survey Results (Total Responses)

		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1.	I have a basic knowledge of organic versus non-organic food options.	**4**	**8**	**20**	**41**	**33**
2.	I prefer organic food options over non-organic options.	**5**	**8**	**26**	**31**	**35**
3.	I buy organic food frequently.	**9**	**25**	**29**	**27**	**16**
4.	I would be willing to pay up to 30% more for an organic food product.	**9**	**31**	**21**	**30**	**14**
5.	I do not buy organic food products due to higher prices.	**16**	**26**	**33**	**20**	**8**
6.	I have a basic knowledge of Genetically Modified Organisms (GMO).	**8**	**17**	**23**	**30**	**24**
7.	I buy GMO-Free products frequently.	**13**	**26**	**35**	**20**	**7**
8.	I typically read labels on my food.	**4**	**9**	**16**	**35**	**41**
9.	I am familiar with aquaponics.	**14**	**26**	**16**	**28**	**18**

10. I believe the benefits of organic/GMO-free food products are: (Check all that apply)

Taste **43** Shelf Life **30** Health Benefits **81** Value **16** Availability **5** None **5**
Other: **6**

11. Where do you typically buy your groceries? (Check all that apply)

Wholesale Store **19** Supermarket **75** Specialty Store/High-end Grocery Store **27** Corner Store **22**
Local Market/Farmer's Market **36** Other: **0**

12. Please explain why you do or do not purchase organic/GMO-Free food products:

Ethnicity/ Race

White/Caucasian **15** Hispanic/Latin **82** Asian/Pacific Islander **2** Black/African-American **2**

Other: **3**

Permanent Residence

Puerto Rico **90** United States **15** Other **1**

Age

18-25: **14** 26-35: **24** 36-45: **20** 46-55: **16** 56-65: **20**
66+: **12**

F. Restaurant Survey Results (Total Responses)

		0%	1-10%	11-20%	21-30%	>30%
1.	What percentage of the food you purchase is organic?	**11**	**18**	**5**	**7**	**5**
2.	What percentage of the food you purchase is grown domestically?	**9**	**9**	**9**	**7**	**11**
3.	What percentage of the food you purchase is GMO-free?	**11**	**13**	**7**	**0**	**4**

		Taste	Price	Convenience	Other (Please Explain)
4.	What is the main reason you do or do not purchase organic products?	**10**	**20**	**10**	**13**
5.	What is the main reason you do or do not purchase GMO products?	**8**	**11**	**11**	**11**

6. Where do you typically buy your produce? (Check all that apply)

Farm **14** Distributors **30** Local Market **24** Other: **2**

7. Would you consider using the following local organic products in your restaurant?

Just Fish **1** Just Produce **13** Fish and Produce **26** None **4**

8. Based on requests from customers, how important are organic/GMO free choices to them?

Not Important **11** Somewhat Important **17** Very Important **19**

9. Are you interested in having a fully serviced, small-scale aquaponic (combination of hydroponics and aquaculture) system in your restaurant?

Yes **11** No **8** Maybe **24**

Why or Why Not? (Please Explain):_____

G. Grocery Store Survey Results

		0%	1-10%	11-20%	21-30%	>30%	I do not know
1.	What percentage of the produce you purchase is from local farms?	**1**	**3**	**5**	**2**	**0**	**0**
2.	What percentage of the produce you purchase is from distributors?	**0**	**0**	**3**	**1**	**6**	**1**
3.	What percent of foods sold in your store are organic?	**4**	**4**	**1**	**1**	**1**	**0**
4.	What percent of foods sold in your store are free of genetically modified organisms (GMO-Free)?	**1**	**3**	**1**	**1**	**1**	**3**
5.	What percent of customers inquire about organic or GMO-Free products?	**1**	**2**	**3**	**1**	**0**	**3**

6. I believe the benefits of organic/GMO-Free products are: (Check all that apply)

Taste **0** Shelf Life **2** Health Benefits **9** Value **1** Availability **1** None **0**
Other: _____

7. Do you have customers who primarily purchase organic products?

Yes **6** No **1** Unable to Determine **4**

8. What organic and/or GMO-Free food products do you sell, if any? (Mark all that apply)

Vegetables **7** Fruits **6** Herbs & Spices **6** Unsure **1** Other: **1**

9. Do you sell organic farm-raised fish?

Yes **4** No **5** Unsure **2**

10. Which food product is of highest demand in your store? (Mark one choice only)

Vegetables **6** Fruits **2** Herbs & Spices **1** Fish **0** Other: **1**

11. Please circle the top three produce with the highest sales in your store.

Asparagus **3**	Basil **3**	Bay Leaves **1**	Bell Peppers **1**	Cabbage **3**
Cauliflower **2**	Cilantro **2**	Cucumber **2**	Lettuce **8**	Mint **0**
Mustard **2**	Onions **4**	Parsley **3**	Sage **0**	Tomatoes **10**

12. Do you have a section in your store devoted to organic products?

Yes **4** No **3**

Why or why not? (Please explain)

H. Interview with WPI Corporate and Professional Education

Date: Thursday February 12, 2013
Interviewers: Katherine Newell, Paige Westlake
Team Secretary: Timothy Granger

The interview began with introductions and a general overview of the group's project goals, specifically relating to professional education programs. Responses have been paraphrased into key points.

Paige Westlake: What type of courses or programs does CPE conduct? Any workshop-type programs?
Rachel LeBlanc:

- Graduate courses
- 10% revenue comes from workshops, ranging in length from 1 day to 8 days
- For individuals, project management certificate
- Workshops all over the world for companies
- Tailored to target markets

Westlake: How do you advertise these adult and or professional programs?
LeBlanc:

- Direct sales and marketing
    - Meet on street, alums, LinkedIn, leadership in companies
    - Networking, radio, public access channels, newspapers
    - Marketing campaigns mostly web
    - Find out if print is better than online material
        - Online generally provides easier access and is less expensive, but it needs to be available
    - Vertical Response
        - Software that sends mass email but tracks what users click, view, etc.
    - Know target audience, i.e. do they have Internet access
    - If sponsors are interested, there are options to pay to come up higher on Google search
    - Contact people who already attended a workshop
    - Inquiry places on website
    - Career centers

Westlake: How do you get contacts?

- Anyone that takes course added to a database

    - Sign-up for emails or interest
        - Lists are set up and divided into appropriate groups
    - Markets are pretty low
    - Depend on sales personal to spread world
    - Google Analytics and word search
        - Pay for keywords
        - Or certain people know how to make it organic

Westlake: What aspects do you think make a successful workshop or class?
LeBlanc:

- Depends on the teacher
    - What is their goal and target focus
    - Know your clients/ target audience
    - Instructor should be engaging
    - Keys to keep people engaged
        - Exercises
            - Students generally maintain 45 minutes of focus
            - Every 45 minutes, a discussion or exercise helps keep the program interactive and keep participants interested
            - Important to keep people focused

Westlake: Do you feel that the overall time length of a workshop or class is important to its success? If so what is the ideal time length of a workshop?
LeBlanc:

- Timing is very important
- Depends on target population
    - Leadership programs are very intense: stay there and sleep, live, and breathe it
    - Management programs occur in increments: one program every few weeks allows time for participants to apply the skills between sessions
    - Awareness course can be a large group lecture
    - Instructional, lab, or hands-on programs should have a smaller class size or be broken into smaller groups

Katherine Newell: The program that our sponsors currently run is about 20-30 people.

    - A class of 20-30 participants is a good size for a hands-on program, 25 max.

- The most important part of any program is to identify the specific goals
- Portion it out
    - Lecture 45 people at time
    - Lab is only 12 people at a time
    - Combination of big lecture, then smaller labs like WPI courses

Westlake: If applicable, what percentage of the total time is typically spent working hands-on versus the amount of time lecturing critical information?

LeBlanc:

- Depends on the topic
    - Not half and half
    - If participants are novices, more lecture time is needed
    - If participants are experienced, more hands-on work
    - A general guideline is 2/3 lecture, 1/3 hands on

Westlake: People that have taken workshop might not come back after the day of the program

- Maybe a follow-up program should be a recommendation
- Set of programs might take 6 months to a year
    - Give information about what steps attendees should take next
    - Make them commit to the workshops schedule

Westlake: What workshop or class size is optimal, where everyone can benefit from the workshop or class and gain a sufficient amount of knowledge from it?

LeBlanc:

- Depends, but generally not above 25 for a program like the workshops your sponsors are implementing
    - Cuts on level of interactivity
    - A large group can create too many ideas and can cause participants to "shut down" and become disinterested
- ABET Labs provide a good example
    - "Walk through" the process
    - Include signage to detail each step of the process, which is a great tool to learn and become accustomed to the process

Westlake: Do you evaluate your workshops, classes, and/or courses in any way? Do you use surveys or interviews to gain this information? What type of questions do you ask?

LeBlanc:

- Yes
- In general, an online survey is sent at the end of every program
- A reminder is sent every week or two weeks (2 times max)
- Good feedback is used for marketing purposes
- Follow-up survey
    - Better to keep similar to the original survey for comparison purposes

Westlake: How long do you wait to send the follow up survey?

LeBlanc:

- Depends
    - With companies, every few months for “check-ins”
- Receive contact information from career centers
    - In MA, can identify job opportunities that require specific skill sets

Westlake: If applicable, what personal information or contact information do you collect from the attendees? Do you ever follow up with attendees on their success?

LeBlanc:

- Ask about quality
    - Was the instructor engaging and stimulate interest in the subject? Was the room or environment sufficient for learning?
    - Basic survey for all participants
    - Important to include demographic information
        - Age, gender, experience level, education, etc.
        - Helps to identify target audience

Westlake: How do you evaluate if the workshop was successful? For example, professors hope their classes are valuable but they often don't know if the information was helpful in later jobs or positions.

LeBlanc:

- Back to the goal: evaluate how well the goal has been met
- Widespread knowledge
    - Might not be individual but the aggregate
    - Create a plan with small steps along the way
    - Reevaluate along the way at each step
        - Must have patience and realistic goals

Westlake: How do you gain or evaluate interest in holding a workshop before creating it? Is it important to understand the interest before planning a program?

LeBlanc:

- Yes
- Do this through focus groups and surveys

I. Interview with Aquaponics Researcher

Date: Friday March 15, 2013
Interviewer: Kyla Wesley
Team Secretary: Paige Westlake

The interview began with introductions explaining our goals for the project. Responses have been paraphrased into key points.

Kyla Wesley: Is there anything involving our survey that you would improve or change?
Chelsea Wright:

- Reword " intellectual challenge" - you want to make sure your surveys are as simple as possible that way the participant will understand what you are trying to ask
- Also have a question pertaining to people that might have a system
- You will be meeting people that already have a system built
    - If they say yes, have questions pertaining to their system
        - What are you doing with your food?
        - Are you selling it?
        - Do you have community support in regards to your system?
        - Do you have an income?

Wesley: How did you look into marketing for this type of produce?
Wright:

- Researched by looking into the industry
    - CSA, farmer's markets, grocery delivery, not a lot of scholarly review on GMO's though
    - Also looked into gardening clubs, high school science, gardening forums, botanical garden – particular to growing food

Wesley: What other ways do you suggest we do in regards to promoting this type of produce?
Wright:

- Maybe you could try and use reusable bags – maybe you could ask the Casas where they got their supplies
- Make stickers
- Or you could take food to different restaurants/ grocery stores and also farmers markets

Wesley: What types of workshops have you taught and/or attended?
Wright:

- I have not taught workshops but have been to workshops held in backyard or commercial farm that brought instructors to the workshops

Wesley: What parts of the evaluations were most beneficial?
Wright:

- It was a collaborative energy, it's never competitive
- People constantly talking about what they loved about the workshop

Wesley: How big were the workshops?
Wright:

- 60 people split to two tracks all day

Wesley: How many hours a day?
Wright:

- 8am-5pm lecture 1 ½ hours – as hands on as possible – put levels of knowledge together – food/transportation included

Wesley: What can we do to get involved with the attendees of the workshop by asking them questions about their input on the workshop?
Wright:

- Engage them – work with Pedro
- Have Pedro ask if we can hold focus group
- Discussion – questions based on Pedro's instructions – hear his presentation in English first

J. Interview with Aquaponics Workshop Instructor

Date: Friday March 15, 2013
Instructor: Pedro Casas Jr.
Interviewers/Secretaries: Timothy Granger and Katherine Newell
Others Present: Chelsea Wright, Pedro Casas Sr., Jorge Casas

***Timothy Granger*:** What is your background in aquaculture/aquaponic technology? Where/when did you learn about aquaculture/aquaponic technology? Where/when did you learn about how to create/conduct a workshop?
***Pedro Casas Jr.*:**

- At the University of the Virgin Islands
- About 6 years of experience
- Mentor: Charlie Shultz (worked and studied aquaponics with Dr. Rakocy)
- Attended total of 4 formal aquaponics trainings
- Also learned by building/ maintaining small-scale systems
- Not formal teaching education or training, but strong personal interest and natural ability
    - Naturally good at explaining and lecturing
    - Patience
    - Passion for teaching
    - Experience through teaching brothers, learned from father ("handyman" skills)
    - Observing other teachers and aquaponics instructors
    - Background in design

***Granger*:** In your opinion, what are the learning objectives for your aspect of the workshop?
***Casas*:**

- Water quality
    - Importance
    - What is good water quality, and how to maintain
    - Must test every day: how to test
        - In just 3-4 days, drastic alteration can occur
    - Documentation
    - "pH is the life of the system"- details and balances are important to know and control
- Gauging interest
    - Get people interested in aquaponics
    - Get a "feel for it"

***Granger*:** What scientific knowledge, if any, do you aim to teach during these workshops?
***Casas*:**

- With only 1-day, focus is not on teaching scientific knowledge
    - Too in-depth
- With a longer training program, scientific knowledge is important
    - Basic Chemistry
    - Nitrogen Cycle
    - Physics of water flow, height of tanks

***Granger*:** What specific skills do you aim to teach during these workshops?
***Casas*:**

- 1-day program does not allow for in-depth lesson on skills
- In longer training, skills are covered (specifically in a construction based training)
    - Plumbing (levels of tubing)
    - Construction
    - Basic Chemistry

Granger: Are there any prerequisite skills or knowledge that an attendee should have before attending the workshop? What follow up training or programs, if any, would you recommend to participants?
Casas:

- Currently, no progression workshop
    - Intention to create progression

Newell: Would you direct interested participants at the 1-day training to attend the 5-day Aquaponics Institute training here in November?
Casas:

- Yes, definitely
- With education programs, credentials are important
    - Aquaponics Institute has a well-run program

Granger: How do you advertise for your workshop?
Casas:

- Mostly Facebook and Facebook ads
- To target interested individuals, filters for Facebook ads are used
    - Gardening
    - Organic
    - Local
    - Fish
    - Hydroponic

Granger: What amount of time is spent with hands-on training versus lecturing? (For aquaponic portion of program)

Casas:

- About 1 hour of lecture
    - Many visuals
    - See how it works and catch attention
- About 1 hour walking around farm and explaining
    - Small open aquaponic system
    - Fish fertilizer in soil, organic nutrients

Granger: Have you received any informal or formal feedback from workshop attendees in the past? If so, what information did you gain from attendees?

Casas:

- No formal evaluations

Newell: Have you gotten any informal feedback?

Casas:

- Yes, generally positive
- Many attendees can see that this can be a real, attainable dream

Chelsea Wright:

- Pedro should have taught all classes at the Aquaponics Institute
- Exactly what people wanted to see
- Gave participants ideas, base projections for success of an aquaponic system
- Good experience for Pedro and participants
- Participants thought Pedro was the best teacher

Granger: Are there any changes that you would make to this program? If so, what changes would you make?

Casas:

- Program and teaching bettering with every workshop
- No specific changes

K. Workshop Evaluation Survey

Please answer the following questions by checking the appropriate box.

		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1.	I currently have or plan to build an aquaponics system.	☐	☐	☐	☐	☐
2.	The presented material was difficult.	☐	☐	☐	☐	☐
3.	The learning materials were beneficial.	☐	☐	☐	☐	☐
4.	The program met most of my expectations.	☐	☐	☐	☐	☐
5.	The time length of the program was too short.	☐	☐	☐	☐	☐
6.	I would recommend this program to others.	☐	☐	☐	☐	☐

Please answer the following questions by checking the appropriate box on a scale of 1-5 where 1 is NOT ENOUGH and 5 is TOO MUCH.

		Not Enough	2	Perfect	4	Too Much
7.	The amount of material presented was:	☐	☐	☐	☐	☐
8.	The intellectual challenge presented by the program was:	☐	☐	☐	☐	☐
9.	The amount of lecture time was:	☐	☐	☐	☐	☐
10.	The amount of hands-on learning time was:	☐	☐	☐	☐	☐

	Very Poor	Poor	Average	Good	Very Good

11.	My overall rating of the quality of this program was:	☐	☐	☐	☐	☐
12.	My overall rating of the aquaponic[1] instructor's teaching was:	☐	☐	☐	☐	☐
13.	The aquaponic instructor's skill in providing explanations was:	☐	☐	☐	☐	☐
14.	My overall rating of the aquaculture[2] instructor's teaching was:	☐	☐	☐	☐	☐
15.	The aquaculture instructor's skill in providing explanations was:	☐	☐	☐	☐	☐
16.	The overall organization of the program was:	☐	☐	☐	☐	☐

17. How do you plan to use the information from this program? (Mark all that apply)

Build/maintain a personal system ☐ Build/maintain a commercial system ☐ None ☐

Other:_____

18. How did you hear about this program? (Mark all that apply)

Facebook ☐ Other online source ☐ Word of mouth ☐ Other:_____

19. Why did you attend this program?

20. What did you particularly like and/or dislike about the program?

[1] Farming technique combining aquaculture and hydroponics
[2] Fish farming

21. Do you have any suggestions for future workshops?

Gender

Male ☐ Female ☐

Ethnicity/ Race

White/Caucasian ☐ Hispanic/Latin ☐ Asian/Pacific Islander ☐ Black/African-American ☐

Other:

Permanent Residence

Puerto Rico ☐ United States ☐ Other ☐

Age

18-25 ☐ 26-35 ☐ 36-45☐ 46-55 ☐ 56-65 ☐ 66+ ☐

Currently Employed

Yes ☐ No ☐

L. Past Participant Workshop Evaluation Survey

Please answer the following questions by checking the appropriate box.

		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1.	I have applied the skills I learned from this program.	☐	☐	☐	☐	☐
2.	I currently have or plan to build an aquaponics system.	☐	☐	☐	☐	☐
3.	The presented material was difficult.	☐	☐	☐	☐	☐
4.	The learning materials were beneficial.	☐	☐	☐	☐	☐
5.	The program met most of my expectations.	☐	☐	☐	☐	☐
6.	The time length of the program was too short.	☐	☐	☐	☐	☐
7.	I would recommend this program to others.	☐	☐	☐	☐	☐

Please answer the following questions by checking the appropriate box on a scale of 1-5 where 1 is NOT ENOUGH and 5 is TOO MUCH.

		Not Enough	2	Perfect	4	Too Much
8.	The amount of material presented was:	☐	☐	☐	☐	☐
9.	The intellectual challenge presented by the program was:	☐	☐	☐	☐	☐
10.	The amount of lecture time was:	☐	☐	☐	☐	☐
11.	The amount of hands-on learning time was:	☐	☐	☐	☐	☐

		Very Poor	Poor	Average	Good	Very Good
12.	My overall rating of the quality of this program was:	☐	☐	☐	☐	☐
13.	My overall rating of the aquaponic[3] instructor's teaching was:	☐	☐	☐	☐	☐
14.	The aquaponic instructor's skill in providing explanations was:	☐	☐	☐	☐	☐
15.	My overall rating of the aquaculture[4] instructor's teaching was:	☐	☐	☐	☐	☐
16.	The aquaculture instructor's skill in providing explanations was:	☐	☐	☐	☐	☐
17.	The overall organization of the program was:	☐	☐	☐	☐	☐

18. How have you used the information from this program? (Mark all that apply)

Build/maintain a personal system ☐ Build/maintain a commercial system ☐ None ☐

Other:_____

19. How did you hear about this program? (Mark all that apply)

Facebook ☐ Other online source ☐ Word of mouth ☐ Other:_____

20. Why did you attend this program?

21. What did you particularly like and/or dislike about the program?

[3] Farming technique combining aquaculture and hydroponics
[4] Fish farming

22. Do you have any suggestions for future workshops?

Gender

Male ☐ Female ☐

Ethnicity/ Race

White/Caucasian ☐ Hispanic/Latin ☐ Asian/Pacific Islander ☐ Black/African-American ☐

Other:

Permanent Residence

Puerto Rico ☐ United States ☐ Other ☐

Age

18-25 ☐ 26-35 ☐ 36-45☐ 46-55 ☐ 56-65 ☐ 66+ ☐

Currently Employed

Yes ☐ No ☐

M. Gantt Chart for Scheduling

	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
On Site Acclamation								
Weekly Farm Visits								
Workshop Instructor Interview								
Aquaponics Institute Researcher Interview								
Attend Workshop								
Distribute Surveys to Attendees								
Distribute Surveys to Past Attendees								
Distribute Restaurant Surveys								
Interview with Wilo Benet								
Distribute Grocery Store Surveys								
Distribute Consumer Surveys								
Data Entry: Workshop Attendee Survey								
Data Entry: Restaurant Survey								
Data Entry: Grocery Store Survey								
Data Entry: Consumer Survey								
Analyze Workshop Data (Interviews, Informal Discussion, and Surveys)								
Analyze Market Data (Restaurant, Grocery Store, and Consumer Surveys and Restaurant Interviews)								
Establish Recommendations for Sponsors								

N. Workshop Evaluation Results (Total Responses)

		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1.	I currently have or plan to build an aquaponics system.	**0**	**0**	**0**	**2**	**8**
2.	The presented material was difficult.	**4**	**4**	**1**	**1**	**0**
3.	The learning materials were beneficial.	**0**	**0**	**0**	**3**	**7**
4.	The program met most of my expectations.	**0**	**0**	**0**	**4**	**6**
5.	The time length of the program was too short.	**2**	**3**	**3**	**0**	**2**
6.	I would recommend this program to others.	**0**	**0**	**0**	**1**	**9**

		Not Enough	2	Perfect	4	Too Much
7.	The amount of material presented was:	**0**	**0**	**9**	**1**	**0**
8.	The intellectual challenge presented by the program was:	**0**	**3**	**6**	**0**	**1**
9.	The amount of lecture time was:	**0**	**1**	**9**	**0**	**0**
10.	The amount of hands-on learning time was:	**0**	**3**	**7**	**0**	**0**

		Very Poor	Poor	Average	Good	Very Good
11.	My overall rating of the quality of this program was:	**0**	**0**	**0**	**3**	**7**
12.	My overall rating of the aquaponic instructor's teaching was:	**0**	**0**	**0**	**1**	**9**
13.	The aquaponic instructor's skill in providing explanations was:	**0**	**0**	**0**	**0**	**10**
14.	My overall rating of the aquaculture instructor's teaching was:	**0**	**0**	**0**	**2**	**8**
15.	The aquaculture instructor's skill in providing explanations was:	**0**	**0**	**0**	**2**	**8**
16.	The overall organization of the program was:	**0**	**0**	**0**	**3**	**7**

17. How do you plan to use the information from this program? (Mark all that apply)

Build/maintain a personal system **6** Build/maintain a commercial system **8** None **0**

Other:_____

18. How did you hear about this program? (Mark all that apply)

Facebook **0** Other online source **3** Word of mouth **4** Other **2**

19. Why did you attend this program?

Varied

20. What did you particularly like and/or dislike about the program?

Varied

21. Do you have any suggestions for future workshops?

No Responses

Gender

Male **9** Female **1**

Ethnicity/ Race

White/Caucasian **1** Hispanic/Latin **9** Asian/Pacific Islander **0** Black/African-American **0**

Other:

Permanent Residence

Puerto Rico **10** United States **0** Other **0**

Age

18-25 **1** 26-35 **2** 36-45 **6** 46-55 **0** 56-65 **0** 66+ **1**

Currently Employed

Yes **7** No **1**

O. "Before" Questionnaire for Workshop Participants

1. Please rate your current knowledge about aquaponics on a scale from 1 to 5, where 1 is "not knowledgeable" and 5 is "very knowledgeable".

Not knowledgeable ☐ 2 ☐ 3 ☐ 4 ☐ Very knowledgeable ☐

2. How many other aquaponics trainings have you attended?

0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 or more ☐

Please indicate which trainings you have attended in the space below.

3. Personal Aquaponics System

Currently have ☐ Plan to build ☐ Do not have or plan to build ☐

4. Commercial Aquaponics System

Currently have ☐ Plan to build ☐ Do not have or plan to build ☐

5. How do you plan to use the information from this program? (Mark all that apply)

Build/maintain a personal system ☐ Build/maintain a commercial system ☐ None ☐

Other:_____

6. What types of information are you most interested in learning? (Mark all that apply)

Introductory aquaponics information ☐
Constructing a system ☐
Water quality maintenance ☐
Plant production (seeding and harvesting) ☐
Operation of aquaculture ☐
Marketing and advertising ☐
Other:_____

7. How did you hear about this program? (Mark all that apply)

Facebook ☐ Other online source ☐ Word of mouth ☐ Other:_____

8. Is there any other information you would like the instructors to know before attending this program?