Establishing a Training Program for Aquaculture Extension Agents in Costa Rica

An Interactive Qualifying Project

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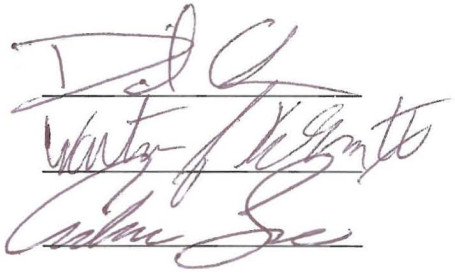

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This report is the product of an education program, and is intended to serve as partial documentation for the evaluation of academic achievement. The report should not be construed as a working document by the reader.

ABSTRACT

The Instituto Costarricense de Pesca y Acuicultura (INCOPESCA) is a Costa Rican governmental organization that manages fisheries and works with aquaculturists. Since INCOPESCA currently has no training program for its extension agents, they have asked us, to help develop this program. To ensure that all issues and viewpoints were considered, we interviewed and surveyed aquaculturists, extension agents, and educators in Costa Rica. We used this information to determine the key obstacles to aquaculture and developed a training program for INCOPESCA's extension agents based on methods of non-formal education that can be used to overcome these issues. These topics include feed, marketing, and equipment.

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Although we wrote first drafts of each section separately. This project was a collaborative effort of all three of the team members. Each group member's contribution to the project was equal.

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Executive Summary

Costa Rica is a developing country with limited resources and limited access to technology. Therefore, many of its industries, including some agro-businesses, are small and could profit greatly from technical assistance. This is precisely the case for freshwater aquaculture in Costa Rica. The governmental organization in charge of providing assistance to small aquaculturists is the Instituto Costarricense de Pesca y Acuicultura (INCOPESCA). Limited in resources, INCOPESCA only has ten extension agents to serve almost 800 aquaculture projects throughout the country. These include shrimp, tilapia, and rainbow trout. This project addresses issues related to trout and tilapia farming. Since for budgetary reasons it would be very difficult for INCOPESCA to only hire more agents and/or purchase more equipment, our project focuses on utilizing the available agents and resources more efficiently.

The objective of our project was to create an educational program that can be used to train the extension agents to improve their knowledge of aquaculture as well as improve the knowledge of the aquaculturists they serve. By improving the assistance that is provided by INCOPESCA and, by extension, the general knowledge of the farmers, we aim to improve the aquaculture industry in Costa Rica as a whole.

We focused on tilapia and trout, which are both cultivated on a small scale by rural farmers. The rainbow trout fingerlings are produced in a hatchery run by INCOPESCA, in the mountains south of Cartago. These are sold to farmers in that area, who raise them and sell the adults to local markets or on their farms for sportfishing.

Tilapia fingerlings are raised in three hatcheries in the warmer lowlands of the country. Seventy percent of Costa Rica's tilapia farmers are located in the San Carlos

area, where there is a marketing co-op that helps distribute their produce to domestic supermarkets and restaurants. Other farmers sell their fish only to local markets and restaurants. There is one large, foreign-owned tilapia aquaculture business, Aquacorporación. However, INCOPESCA only works with the small farmers, who need their technical assistance.

To determine the extent of the problem, and to find out what specific issues were important to the aquaculturists and extension agents, we conducted two surveys, one for farmers and one for agents. To gain more in-depth information, we informally interviewed aquaculturists and extension agents. To get a scientific viewpoint we interviewed an aquaculture educator at the Universidad Nacional in Heredia. We also visited both trout and tilapia farms of various sizes.

The survey results indicated that for the aquaculturists, marketing of their fish was an important concern, especially for the trout farmers. They also needed equipment, specifically: water quality testing devices, size selectors for fish and eggs, and nets. Most aquaculturists felt that training would be very helpful, especially on diseases, food, and feeding. The extension agents typically had over twenty years of experience and at least a bachelors degree. They agreed that marketing and training in aquacultural techniques were the important issues for the farmers. Training in reproduction methods was the most important item about which the agents themselves wanted more education.

To solve these problems, we suggest an informal training program for the extension agents on different informal educational methods so they can become more effective educators. We have also included a list of different issues that are most important to be taught to both parties. For the extension agents, we recommend mostly

self-directed study to improve their technical knowledge, and have included an extensive list of resources. Since the extension agents are already spread thin, we recommend that the less experienced aquaculturists utilize the veteran farmers in the area. Through mentoring, meetings, and associations farmers will be able to learn a lot of practical information directly from their peers. The extension agents can provide regular workshops for the experienced farmers, as well as possibly providing them with discounted fish fry for their services.

Since technical knowledge is not the only thing required to run a business, we also suggest some ways to improve the marketing and equipment of aquaculturists. While the tilapia farmers have a co-op that helps them sell their products to larger markets, the trout farmers have no such organization, and many are not able to sell their trout outside of their farms and neighborhoods. We recommend that INCOPESCA help initiate a co-op for trout farmers in the Cerro la Muerte area. This would also make it easier for beginning farmers with very little production to find immediate markets at competitive prices. To maximize the efficiency of the equipment that is owned by INCOPESCA and farmers, we suggest a loan program, through which farmers could borrow equipment from INCOPESCA or other farmers in their local areas.

By promoting farmer co-ops, and utilizing informal training methods, INCOPESCA can more effectively develop Costa Rican aquaculture. As the markets and farmers expand, the industry will become a more important part of the economy, and hopefully INCOPESCA will be able to expand its extension capabilities. For now, however, INCOPESCA needs to focus on making the best use of what resources they have to aid the development of the up-and-coming industry.

RESUMEN EJECUTIVO

Costa Rica es un país en vía de desarrollo con recursos limitados y limitado acceso a la tecnología. Por lo tanto, muchas de sus industrias incluyendo algunos negocios agrícolas, son pequeños y ganarían grandemente de una asistencia técnica. Este es precisamente el caso de la acuacultura de agua dulce en Costa Rica. La organización gubernamental a cargo de proveer la asistencia a los acuicultores es el Instituto Costarricense de Pesca y acuicultura (INCOPESCA). Limitado en recursos, INCOPESCA solamente tiene diez agentes de extensión para servir a alrededor de 800 proyectos de acuicultura a lo largo de todo el país. Esto incluyen: camarón, tila pía, y trucha arco iris. Este proyecto se concentra en asuntos relacionados con el cultivo de trucha y tilapia. Debido a razones de presupuesto seria muy difícil para INCOPESCA poder solamente contratar a gentes o comprar mas equipos. Este proyecto se enfoca en utilizar los agentes disponibles y los recursos mas eficientemente.

El objetivo de este proyecto era crear un programa educacional que pueda ser usado para entrenar los agentes de extensión a mejorar sus conocimientos en acuicultura así como mejorar el conocimiento de los acuicultores a los cuales sirven. Al mejorar la ayuda que es proveída por INCOPESA y por extensión, el conocimiento general de los acuicultores, se desea mejorar la industria de acuacultura en Costa Rica como un todo.

Se enfoco en tilapia y trucha, las cuales ambas son cultivadas a pequeña escala por acuicultores rurales. Los peces jóvenes de las truchas arco iris son producidas en una incubadora manejada por INCOPESCA, en las montañas al sur de Cartago. Estos

son vendidos a acuicultores en esta área, quienes los crían y los venden los adultos a los mercados locales o en sus fincas para la pesca deportiva.

Los peces jóvenes son criados en tres incubadoras en las tierras bajas mas calientes del país. El setenta por ciento de los acuicultores de tilapia están localizados en el área de San Carlos, donde hay una cooperación de mercadeo que asiste en distribuir su producto a los supermercados y restaurantes locales. Otros acuicultores venden sus pescados solo a los mercados y restaurantes locales. Hay un gran negocio de acuicultura de tilapias en manos de extranjeros, Acuacorporación. De todos modos INCOPESCA solamente trabaja con el pequeño acuacultor, el cual requiere su asistencia técnica.

Para determinar la extensión del problema, y encontrar cuales asuntos específicos eran importantes para los acuacultores y agentes de extensión, se condujeron dos encuestas: una para acuacultores y otra para agentes. Para conseguir mas información exhaustiva, se entrevisto informalmente a acuacultores y agentes de extensión. Para conseguir un punto de vista científico se entrevisto a un educador de acuacultura en la Universidad Nacional en Heredia. También se visito ambas fincas de trucha y tilapia de diferentes tamaños.

Los resultados de la encuesta indicaron que para los acuicultores el mercadeo de sus pescados era un asunto importante, especialmente para los criadores de truchas. Ellos también necesitaban equipos, específicamente: instrumentos de para examinar la calidad el agua, seleccionadores de tamaños para los peces y huevos redes. La mayoría de los acuicultores sentían que el entrenamiento seria de gran ayuda, especialmente en enfermedades, comida y alimentación. Los agentes de extensión típicamente tenían mas de veinte años de experiencia y por lo menos un grado de bachillerato universitario. Ellos

tuvieron de acuerdo que el mercadeo y entrenamiento en técnicas de acuacultura eran los asuntos importantes para los acuacultores. El entrenamiento en los métodos de reproducción era el tópico mas importante sobre el cual los mismos agentes querían mas educación.

Para resolver estos problemas se sugiere un programa de entrenamiento informal para los agentes de extensión en diferentes métodos informales de educación para así convertirse ellos en educadores mas efectivos. También se incluyo una lista de los diferentes asuntos que son mas importantes para enseñar en ambos grupos. Para los agentes de extensión, se recomienda mayoritariamente un estudia autodirigido para mejorar su conocimiento técnico, y se ha incluido una extensiva lista de recursos.

Debido que los agentes de extensión ya están sobre utilizados por la gran extensión a cubrir, se recomienda que los acuicultores con menos experiencia utilicen los cultivadores veteranos en el área A través de consultaría, reuniones y asociaciones de cultivadores serán capaces de aprender mucha información practica directamente de sus compañeros.

Los agentes de extensión pueden proveer talleres regulares para los cultivadores con experiencia, así también como posiblemente proveyéndoles con precios cómodos de pescado frito por sus servicios.

Ya que los conocimientos técnicos no son los único requerido para administrar un negocio, también sugerimos algunas formas para mejorar el mercadeo y equipo de los acuicultores.

Mientras los cultivadores de tilapia tienen una cooperativa que ayudan a vender sus productos a mercados mayores, los cultivadores de truchas no tienen tal organización

y muchos no son capaces de vender las truchas fuera de sus granjas o vecindarios. Recomendamos que INCOPESCA ayude a iniciar una cooperativa de cultivadores de truchas en el área del Cerro de la Muerte. Esto haría que las cosas fueran mas fáciles para cultivadores principiantes con poca producción para encontrar mercados inmediatos a precios competitivos. Para maximizar la eficiencia del equipo propiedad de INCOPESCA y cultivadores, sugerimos un programa de prestamos, a través de la cual los granjeros pueden pedir prestado equipo perteneciente a INCOPESCS o otros cultivadores en las áreas vecinas.

Por medio de la promoción de cooperativas de cultivadores y la utilización de métodos informales de entrenamiento INCOPESCA podrá desarrollar en forma mas efectiva la acuicultura Costarricense. En cuanto los mercados y las granjas expandan, la industria se convertirá en una importante parte de la economía, y con optimismo podrá expandir sus capacidades de extensión. Por el momento, sin embargo, INCOPESCA, necesita enfocar en aprovechar a la máximo los recursos que tienen a mana para ayudar al desarrollo de la prometedora industria.

Chapter 1: Introduction

Aquaculture can be a business that prevents the identity and culture of rural communities from being destroyed by large-scale industries. With a small grant or loan from their government or an international lending organization, farmers can set up aquaculture ponds in their own backyards. These small ponds can be used to produce fish to sell in local markets and generate extra earnings for the farmer. With governmental assistance, it is also possible for small fish or shrimp farmers to export their products to international markets. The benefits, if properly managed, can bring badly needed income to local communities. A sustainable microenterprise such as this provides communities with the ability to develop themselves independently, without becoming reliant on any large or foreign companies. Within Costa Rica the Instituto Costarricence de Pesca y Acuicultura (INCOPESCA) is the governmental organization that is responsible for developing the nation's aquaculture industry. This agency helps small farmers begin their businesses, providing them with technical assistance and other types of support.

Although Costa Rica is not a country devoid of technology and assets, a large section of the country (areas outside of the Central Valley) is underdeveloped and dependent on fluctuating coffee, cattle, or banana prices and tourism. Diversification of the economy, as through aquaculture, is beneficial to protect against the loss of such markets or decreases in prices for cash crops, or a general international depression. Aquaculture is an alternative enterprise that, if

managed properly, requires neither the loss of highly valued tropical forest, nor intensive and exploitative labor, nor depletion of the soil and other natural resources (Sorgeloos, 2000, Sustainable Aquaculture Development).

INCOPESCA works with local aquaculturists, providing them with education and technical assistance. However, the organization lacks an effective instructional program to fulfill this part of their mission. INCOPESCA has asked us to help with this problem. Our research has focused on documenting the extent of aquacultural knowledge among Costa Rican aquaculturists, identifying new aquacultural techniques used elsewhere in the world, and discussing the advantages and disadvantages of introducing new, or biologically engineered species of fish into Costa Rica. We have also recommended methods by which INCOPESCA extension agents can effectively distribute new information to aquaculturists.

INCOPESCA asked us to research ways to expand the development of aquaculture in Costa Rica. To address this problem, we created a list of sources of new and different aquacultural techniques and practices. The list contains: professional organizations, societies, and institutions, as well as colleges and universities with aquaculture programs that can be contacted by INCOPESCA in the future or that publish information on aquaculture. These sources can be used by INCOPESCA employees to better educate rural aquaculturists who may not otherwise have access to such information. The extension agents can use this list to keep themselves updated on the latest techniques, as well as to provide resources for distribution to farmers who desire more training.

In order to help address INCOPESCA's need for a training program for their extension agents, it was necessary for us to become familiar with their organization's goals and current training methods. To accomplish this we interviewed and distributed questionnaires to aquaculturists as well as INCOPESCA extension agents. Their knowledge of aquacultural practices was assessed as well as their levels of education. Another important aspect of the project was to gain knowledge about different types and styles of education and training used in Costa Rica. While in the United States, we researched the current literature on aquaculture, non-formal education and training programs, as well as information about Costa Rica and its educational system. We also conducted interviews with knowledgeable aquaculturists and aquaculture educators in the U.S. This information helped us to determine the best methods for instructing INCOPESCA agents and to identify the most effective ways to train the aquaculturists in Costa Rica.

Through our surveys, interviews, and other research we have developed a plan for INCOPESCA to improve its extension services. While we do not have the technical training to make specific suggestions as to what the extension agents should teach the farmers, we have provided a list of different non-formal educational methods that can be utilized to effectively educate the aquaculturists. We have also provided a list of topics that are important for the agents to teach the aquaculturists according to our surveys. Finally, we have included sources that the extension agents can use to obtain more aquacultural information.

This report was prepared by members of Worcester Polytechnic Institute Costa Rica Project Center. The Relationship of the Center to INCOPESCA and the relevance of the topic to INCOPESCA are presented in Appendix A.

Chapter 2: Literature Review/Background

2.1 Introduction

The objective of our project is to establish a training program for INCOPESCA's extension agents, so that Costa Rican aquaculturists will have more assistance with their businesses. This task requires addressing numerous social as well as technical issues. In the United States, as well as in Costa Rica, we have read and digested as much as possible of the available literature on the subjects pertaining to our project. The information was obtained from books, journals, websites, and personal communications. We attempted to find multiple sources for each topic and have included different points of view of the issues, or the consensus where appropriate. What follows is a review of these sources, and background knowledge that was necessary before making our final recommendations.

2.2 Aquaculture Background

Fish have been used as a food source for thousands of years. Before any type of agriculture had been discovered, people obtained food by hunting and gathering, including fishing. Fish is an excellent source of nutrition for a balanced diet, and a very good source of protein. Throughout the centuries, people have discovered increasingly better ways of catching fish, from using primitive hooks and lines to nets, to the huge modern fleets of commercial fishing boats that leave

port for weeks at a time and come back with thousands of pounds of fish. The technology for catching fish has become so refined that people can find them and catch them under almost any circumstances, as long as the fish population is not destroyed. Fishing has also become a favorite pastime in many cultures, and sport fishing, like most tourist activities, can be very profitable for guides. One sport fisherman today can easily spend several thousand dollars to catch only a couple of fish.

The problem is that with the use of new technologies and the huge growth in demand for the fish, the world's lakes, rivers, and oceans cannot support the massive harvesting of fish resources. Alarmingly, it has become apparent that the stocks of wild fish are declining, and it is harder and harder to meet demand simply by going out and catching fish. In the 20th century it became apparent that new methods of raising fish needed to be developed, for instance, through fish farming. In fact, aquaculture has been around since ancient Greek and Roman times and possibly longer than that; however, not until recently has it been used on a large scale (Bardach, 1972, pp. 1-5).

Aquaculture can be an inexpensive and reliable way to raise massive amounts of fish both for sale on world markets and for use as game fish. With the right location, new technology, and a basic knowledge of proper water temperature, food and nutrition, water type, and biological pathogens, an aquaculture farm can be very successful.

2.2.1 Costa Rican Aquaculture

Because it is very close to both the markets of Latin America and North America, Costa Rica is an excellent location for aquaculture. People in North and South America are willing to pay high prices for fresh fish, which can be raised cheaply in Costa Rica. Fish can also provide a healthy and inexpensive form of protein to sell in local markets. Further, the great number of tourists in Costa Rica creates a large market for trout and trout fishing ponds. Many resorts stock their ponds with trout or the native guapote and charge users by the pound for the fish they catch.

Along with the advantages of local demand and close proximity to foreign markets, Costa Rica also has a very good climate for aquaculture. Temperature is a very important factor in raising fish. Since fish are cold-blooded, a temperature change of a couple of degrees can affect the fish very much. However, if a constant temperature can be maintained, fish thrive. In Costa Rica the temperature doesn't change very much over the course of the year, making it very cheap and easy to regulate the temperature on a fish farm (Bardach, 1972, p. 164). For instance, the lowlands and lower valleys in Costa Rica are very warm, providing an excellent environment to raise tilapia. For proper growth, tilapia prefer temperatures between 26.7 and 30.5 degrees Celsius, and to spawn, temperatures greater than 22.2 degrees are necessary. However, temperatures below 12.7 degrees are lethal, which means tilapia farms in the U.S., in winter, need to be heated. In the mountains of Costa Rica there is a very temperate climate with low temperatures around 15 degrees Celsius and highs around 26 degrees Celsius.

These temperatures are ideal for raising trout. Trout prefer temperatures between 13 and 19 degrees Celsius. These temperatures are found in the ponds and rivers of the mountains of Costa Rica, making it a perfect place for raising trout.

2.2.2 Nutrition

Besides temperature, proper nutrition is a very important part of raising healthy and large fish. Nutrition can be fairly easy to regulate. First you need to know the type of fish being farmed, what vitamins and minerals are needed for its healthy growth, the nutrients already in the water and the type of food the fish eats. After finding out what the fish needs to grow in size, various fish foods can be bought from different companies, based on its nutritional needs.

Table 2.1: Proportion of Food to Percentage of Biomass of Tilapia.

(INCOPESCA, 2002, Sistemas De Cultivo)

Weight (grams)	Ration of food in % weight / day
1-5	10
5-10	6.3
10-20	5.2
20-50	4.6
50-70	3.3
70-100	2.8
100-150	2.2
150-200	1.7
200-300	1.5
300-400	1.3
Greater than 400	1

Table 2.1 shows the amount of food needed per day for a tilapia throughout its growth cycle. For example, a 50-70 gram fish needs 3.3% of its body weight in food per day.

Besides the amount of food, the composition of the food can determine a fish's growth rates and health. In the following tables, information is given on the ideal American and Costa Rican ingredients of typical pellets that are fed to tilapia and trout. These can be supplemented by insects for trout, or plants for

tilapia, if the fish are kept in outdoor structures. In earthen ponds, there is a much greater capacity for natural foods to grow, and therefore the minerals and vitamins in the feed are less important.

Table 2.2 details the nutritional components in tilapia food made from different materials in different countries. The feed companies in Costa Rica all import their ingredients, mainly corn and soybeans, from the U.S., which is one of the reasons that the food is expensive (A. Otarola, personal communication, June 13, 2002). It is possible that if the Costa Rican companies used locally grown ingredients they could reduce the price of the food and still maintain the necessary nutritional components.

Table 2.2: Tilapia Foods from Different Ingredients (Jauncey, K. B., & Ross, B., 1982)

Ingredients	Dry Matter	Crude Protein	Crude Fiber	Ash	Ether Extract (Fat)	Carbs	Calcium	Phosphorus
oilmeal with hulls, solvent extracted	89.2	49.9	5	6.3	0.7	38.1	0.2	0.76
oilcake with hulls, mechanically extracted	91	44	8.1	7.5	7.7	32.7	0.2	0.73
oilcake without hulls, mechanically extracted	92.3	47.7	12.5	6.6	5.4	27.8	0.22	1.34
oilmeal without hulls, solvent extracted	89.8	46.1	15.1	7.1	0.7	31	0.17	1.36
oilmeal without hulls, solvent extracted (Israel)	89.9	57.7	6.8	7.3	1.3	26.9	0.19	0.59
oilcake without hulls, mechanically extracted (Tanzania)	92.6	49.5	5.3	4.5	9.2	31.5	0.11	0.74
B. campestris: oilmeal solvent extracted (Canada)	92	44	10.1	7.8	1.2	36.9		
B. napus: oilcake, mechanically extracted (India)	87.2	32.1	12.3	12.9	10.4	32.3	0.5	0.8
oilmeal without hulls, solvent extracted	90	42.7	16.1	7.7	4	29.5		
oilmeal with hulls, solvent extracted. (Zimbabwe)	91.3	26.7	37.8	5.7	4.6	25.2		
oilcake, mechanically extracted (Israel)	90.7	46.4	8.9	13	6.6	25.1	2.09	1.1
oilmeal, solvent extracted (Iraq)	94	44	8.2	14.9	1.4	31.5		
oilmeal, solvent extracted (Iraq)	93.4	20.5	26.1	7	0.4	46	0.08	
oilcake expeller (Trinidad)	88.8	25.2	10.8	6	5.2	52.8		0.67
kernel, oilcake, expeller (Nigeria)	91.6	20.4	9	5.7	8.3	56.6		
kernel, oilmeal, solvent extracted (Ghana)	90.8	18.6	37	4.5	1.7	38.2	0.31	0.85

Table 2.3 lists what one group of specialists believes to be the ingredients that promote the quickest growth of tilapia. Fat, protein, and fiber levels are generally the most important ingredients, and the ones that vary between manufacturers.

Table 2.3: Ideal Diet for Tilapia (Espinosa de los Monteros, J. & Labarta, U., 1988)

Type	**Fat**	**Protein**	**Carbs. (Digestible)**	**Fiber**	**Lysine**	**Metionia + 50 of cistine**
up to 0.5g	10	50	25	8	4,1	1,7
0.5g – 35g	8	35	Equal	8->10	4,1	1,7
35g and up	6	30	Equal	10	4,1	1,7

Table 2.4 lists the percentages of essential ingredients used by a manufacturer of tilapia feed in the U.S., Stohll Design. The protein levels are adequate for young tilapia, and the fat is even a little high for tilapia under 0.5 grams. The fiber levels are lower than what is recommended by the ideal diet; unfortunately the digestible carbohydrate levels are not listed.

Table 2.4: Ingredients in American Tilapia Food (Stohll Design, 2001)

Ingredient Analysis:	
Crude Protein (min)	38%
Sodium (actual)	0.22%
Crude Fat (min)	11%
Vitamin A (min)	15,000 IU/Kg
Crude Fiber (max)	3.00%
Vitamin D3 (min)	3,000 IU/Kg
Calcium (actual)	1.20%
Vitamin E (min)	100 IU/Kg
Phosphorous (actual)	0.90%

Table 2.5 lists what a major tilapia feed company in Costa Rica, Aguilar y Solis, includes in its tilapia food. Their protein levels were suitable for adult tilapia but not optimum for those smaller than 35 grams. The crude fiber levels are closer to the recommended levels, but are still two to four percent lower than desirable. The rest of the ingredients are comparable to those of U.S. companies.

Table 2.5: Ingredients in Costa Rican Tilapia Food (Aguilar y Solis)

Moisture Content (max)	13%
Crude Protein (min)	30%
Crude Fiber (max)	6%
Separating Agent (min)	3%
Metabolizable Energy (min)	2,600 kcal/kg
Calcium (min)	1%
Phosphorous (min)	1%
Sodium (min)	0.20%
Sodium (max)	0.30%

Fish need different amounts of protein, fat, and sometimes fiber as they develop. Table 2.6 shows what one source states to be the necessary levels of each ingredient, for the three stages in a trout's life. This can be compared both to the trout food in the U.S. and in Costa Rica.

Table 2.6: Ideal Nutrition for Trout (Espinosa de los Monteros, J. & Labarta, U., 1988)

Type	Protein	Fat	Lysine	Metionina	Carbs	Fiber	Phosphorus
Fry	50	15			<20,0	<6,0	>=0,8
Fingerling	40	12	5	4	=	=	=
Adult	35	9			=	=	=

Table 2.7 explains what one trout food company, Taplow, includes in its food. The protein levels are high for adult trout, and the fat levels are higher than the ideal levels according to Espinosa de los Monteros (1988).

Table 2.7: Ingredients in American Trout Food (Taplow, 2002)

Moisture Content (max)	10%
Crude Protein (max)	42%
Crude Fat (min)	18%
Crude Fiber (max)	3%
Ash (max)	10%
Vitamin A	7,500
Vitamin D	2,000
Vitamin E	100
Vitamin A	100

Table 2.8: Ingredients in Costa Rican Trout Food (Alimentos del Valle, 2002)

Moisture	Protein	Fat	Fiber	Energy
10%	44%	4%	5%	2400 Kcals

Table 2.8 list the ingredients in a Costa Rican Trout food company: the protein levels are high for an adult trout, according to Espinoza, however the fat levels are lower than recommended, and much lower than the American company. The fiber is slightly higher than an American company, but within Espinosa's suggested maximum limit.

2.2.3 Water Quality

The type of water the fish is raised in has a lot to do with its nutrition. The levels of certain minerals, salts and other substances in the water have to be watched closely to be sure that the fish stay healthy (Bardach, 1972, pp. 164-165). In the water the most important item that needs to be monitored is the oxygen level. Water can be oxygenated very easily with something as simple as a water wheel. The density and type of fish determine how much oxygenation is needed, which in turn determines the method. For small-scale projects, a simple stepladder that the water cascades over (increasing the surface area of the water) may be sufficient. For more intensive projects, fountains or expensive forced aeration pumps may be required. However, it is important to realize that fish require different amounts of oxygen at different times. For example, when fish are feeding, they use 50% more oxygen then when they are not.

2.2.4 Pathogens

Biological pathogens, diseases, and parasites can adversely affect the health of the fish being farmed as well. It is important to know the dangers of these problems and also the early warning signs. If some fish in a tank begin to die of certain pathogens, and it is not recognized and treated early on, the effects can be devastating on the entire farm and could cause huge losses. According to Professor Jeffrey A. Tyler of Worcester Polytechnic Institute, an entire population of fish can be wiped out in a very short period of time if they are not treated promptly (Personal communication, April 17, 2002). It is necessary for a farmer to have some basic knowledge about the pathogens that can be found in Costa Rican waters and how to treat the fish quickly and effectively if a disease is present. Knowledge of the types of fish that are most susceptible to certain diseases and ones that are most resistant to disease will help in choosing a fish that is easy to raise without problems (Dogiel, Petrushevski, & Polyanski, 1961, pp. 1-15). Unfortunately, many diseases have no cure, are endemic to the population, or are almost impossible to prevent. In many cases, once a disease has entered a fish population the only way to get rid of the disease is to remove the fish and sterilize all the tanks and equipment. For many businesses this is not feasible, and if a disease is not lethal or dangerous, the outbreak is allowed to continue. The best procedure for aquaculturists to take to prevent disease is to avoid stressing the fish. This allows the fish's natural defenses to combat disease,

and if the fish contracts the disease, it will help prevent mortality (R. Latorte, personal communication, April 17, 2002).

2.2.5 Aquaculture Systems

When starting an aquaculture farm it is important for aquaculturists to consider where they are going to raise the fish. The first thing an aquaculturist has to consider is the type of containment system. There are two basic systems, closed and open. An open system is typically a simple outdoor pond; it is considered open if there is an inlet and an outlet. An open system is best suited for situations where the temperature does not need to be monitored and they are not worried about fish escaping and mixing with local populations of fish. When considering an open system it is also important to be sure that there is nothing in the surrounding environment that you don't want to get into the pond, for example young or small fish in an open system are easy prey for predators such as birds or otters. Open systems work very well for farms in which the fish are raised to be used for sport fishing or if an aquaculturist doesn't have enough money to build a closed system. If an open system is not working well or is not feasible because of the problems stated above, a closed system will be necessary. The water in a closed system is recycled, so nutrient levels and other factors become important to maintain fish health. In a closed system, temperature and water quality can be closely monitored; it is also easier to be sure that fish do not escape into the wild, or that wild fish and diseases do not get into the pond.

2.2.6 Fish Density

After deciding on the type of system it is important to determine how many fish you want to fit into the pond. There are 4 basic classifications for this and each one is appropriate for different situations:

Semi-intensive: 5-25 fish per cubic meter

Intensive: 26-100 fish per cubic meter

Super intensive: 100+ fish per cubic meter

The last classification is extensive, in which there is a relatively small number of fish per cubic meter. The numbers may be greater than 5 per cubic meter; the difference between extensive, semi-intensive, intensive, and super-intensive is that in an extensive system the farmer does not feed the fish; they forage for natural food in the pond or stream they are raised in. As a farm moves from having an extensive or semi-intensive pond to an intensive or super-intensive pond there are more and more problems with disease, water quality, and oxygen levels in the water. They also have problems concerning proper feeding and getting rid of wastes.

An Average producer of trout in the United States produces 42,500 kg of trout a year (North Carolina, 2000).While Costa Rican trout farmers produce on average only 971 kg per farmer (INCOPESCA stats). The difference in average production of trout is 41,500, this is caused by the fact that Costa Rican Trout farmers is done mostly on a small scale, but it also indicates that they can improve

aquaculture techniques. The average tilapia farmer in United States produces 22,700 kg of tilapia (North Carolina). Compared with Costa Rican Tilapia farmers who produce on average 16,100 kg of fish per year (INCOPESCA stats). The Difference in tilapia production is 6,600 kg per farm, this is also caused by the fact that tilapia aquaculture in Costa Rica is done a smaller scale but it shows that there is area for improvement of production in Costa Rica.

2.2.7 Finding the Latest Aquaculture Information

Modern technology can be very beneficial in fish farming. With new discoveries in the field of biological engineering, fish can be engineered to be resistant to most diseases. New technology in farming methods, packaging, and shipping can be very useful in growing and selling fish. Modern technology is used in building the tanks or ponds for the fish to grow in. Technology is used in the water circulation system to keep the proper amounts of oxygen in the water and in the filtration systems to get rid of wastes from unused food and biological waste from the fish being farmed. There are new methods for feeding the fish and also for regulating the temperature of the water. Fish that are raised on a farm or in a laboratory can also be bred to grow much quicker and much larger than wild fish.

2.2.7.1 Aquaculture Websites

There are several different sources of information on the newest aquaculture techniques. These include scientific journals, aquaculture magazines,

reports from universities specializing in aquaculture, and websites on the internet that specialize in aquacultural information. The web is especially helpful because the information is very recent, easy to access, and many sources can be consulted quickly.

On the Internet, the website ICLARM.org is very informative. It includes links to pages containing information about training, new research reports, project web pages, outreach sites, and an online library. Included in the outreach site, there is a Caribbean and Eastern Pacific link that has a local center with phone numbers and an email address. This site is based in the Virgin Islands and should be especially relevant for Costa Ricans because it has information pertinent to aquaculture in the area (ICLARM, 2002).

Another useful website is the Massachusetts Office of Coastal Zone Management: Aquaculture White Pages, http://www.state.ma.us/czm/wptoc.htm. This includes information on aquaculture, commercially important fish, fish health, drugs and chemicals, genetics, state and federal facilities, laws and regulations, economics, and public safety. This site gives insight into the use of genetic engineering in aquaculture and the laws governing it. It also presents information about the problem of introducing new species to new environments. It also includes lots of links to other aquaculture sites. The problem with this site is it is mostly concerned with aquaculture in the US, mainly in Massachusetts, and a lot of the information may not be as relevant in Costa Rica (Massachusetts Office of Coastal Zone Management, 2002).

Many different places have different techniques for raising fish, and different plans on how to do it. The INCOPESCA website, http://www.mag.go.cr/incopesca/uno.htm, gives good step-by-step instructions on how to grow tilapia and what to feed them. The Virginia Cooperative Extension website, http://www.ext.vt.edu, also has a very good step-by-step explanation about how to develop an aquaculture farm (from getting the fish fry and building the tanks to training and educating employees on how to run the farm). It also presents information about different legal problems with starting a fish farm and any taxes that may be involved.

The World Aquaculture Society (WAS) also has a web page; it has over 4,000 members, and is in 94 countries all around the world (WAS, 2002). It also has information on publications, training, equipment, education, employment, and links to other aquaculture sites. This website has an online store with books and CDs on all of the newest diseases, treatments, and techniques to farm certain fishes. Although this site has a lot of information, including a lot in Spanish, it does require membership, which costs $100 a year for a corporation or $60 a year for an individual. However, it does contain a Latin American chapter and is trying to increase the exchange of information among people who want to know more about aquaculture and those who don't have access to information. It also has links to all of its members so that if anyone finds out a new aquacultural techniques, it can be shared quickly and easily (WAS, 2002).

A few more sites on the Internet are www.aquanic.org, an aquaculture information center, and also the UN page on fish and fish regulations. All of these

websites are very good sources of information, but they also share the problems of all websites. Because there is no one to monitor the information posted on the websites, the information could be wrong or could simply not have been tested enough to be completely accurate. The World Wide Web is a good place to learn about cutting edge technology, but it is also a good place to be fooled by people who have done very little research and have no credentials. All information on these websites should be carefully analyzed, and it should be confirmed that the people who posted the information know what they are talking about. Although the websites cited above are very credible—one is a government site, the other two are well known in the aquaculture world—the links off of these sites should be critically analyzed because they could contain improper or misleading information.

2.2.7.2 Aquaculture Journals

More reliable sources of current information on aquaculture are journals with an aquaculture focus. Several journals can be found through most libraries, including the Journal of Aquaculture, Progressive Fish Culturist Journal, also the Journal on Aquatic Conservation. The Journal of Aquaculture covers the newest technologies in aquaculture and also the newest research done in the field. However, the journal is based in Amsterdam, and some of the information may not be relevant to Costa Rican aquaculture. The Journal on Aquatic Conservation has information about changing the natural habitat when building aquaculture facilities, and also the problems with introducing new species into an area. It

should be a good source of information on the dangers that may occur if exotic species get out of the aquaculture farms and into the wild and how they will react with local species. Another excellent source of ecological information is the Fish Biogenics Model, published by the sea grant program at the University of Wisconsin. This book describes the physiology of fish growth, correct temperatures for fast growth, diseases and how to treat them, and models for all fish growth and nutrition. It was started as an academic tool but is becoming more popular as an aquaculture handbook in the U.S. (J. A. Tyler, personal communication, April 17, 2002).

Like the Internet, journals are a good source of current information, however they can be expensive, and it is hard to determine which ones to buy and which ones not to buy. The information in journals can also be a lot more credible than that of Internet sites and does not need to be looked at with as much scrutiny as web site information. This is because journal articles are approved by editors or peer review, and are typically written by respected professionals in the field. The information written in websites has no such requirements. The main problem with journals is accessibility, sending journals from the United States or Europe to Costa Rica is expensive, and they are often not translated into Spanish. However, currently a lot of journals are available over the Internet (often for a fee), which makes them much more accessible.

2.2.7.3 Aquaculture at Universities

Colleges and institutions are also reliable sources of information on aquaculture and, very often, the newest technologies having to do with aquaculture. Academic institutions with aquacultural programs are always teaching and researching the latest techniques related to aquaculture. Having access to information that is developed at these schools can be invaluable to an aquaculturist. Scientists not only develop new ways to grow and feed the fish but are also doing research on pathogens and genetic engineering. A couple of institutions that have aquacultural programs include the University of Alabama, Auburn University, Ohio State, Kansas State University, University of Arizona, and Malaspina University. Researchers at these institutions are constantly carrying out research and publishing new information on aquaculture that could be very valuable to Costa Rican aquaculture.

Universities can have a lot of new information on aquaculture; the main problem is there is no other way to get this information without consulting the scholars doing the research, unless it is published. Also, much like journals, there are so many schools doing research on so many different subjects, it is hard to keep track of the most relevant and important ones.

2.2.7.4 Aquaculture Associations

There are professional societies that keep up-to-date on the latest research being done. One example is the American Fisheries Society (AFS), which is an organization for both academics and non-academics involved in the industry.

AFS promotes the exchange of information and helps universities make their research more readily available. For tilapia, there is the American Tilapia Association, http://ag.arizona.edu/azaqua/ata.html, which contains knowledge for tilapia farmers, those interested in joining the business and consumers. The World Tilapia Association, http://www.cherrysnapper.com/, encourages multilingual communication at all levels of tilapia production with a newsletter and bulletin boards on their website. The World Aquaculture Association, http://www.was.org/, has information about all types of aquaculture and is committed to developing and sharing the most recent information and technologies throughout the world.

2.2.8 Genetic Engineering in Aquaculture

It has been discovered that a gene can be introduced into Atlantic salmon to make them grow to market weight in about half the time it would normally take wild salmon. Genetically engineered fish have not yet been approved in the U.S. by the Food and Drug Administration (FDA), and the techniques have not been perfected enough to become profitable. However, it is likely that in the near future the technology will be available. The question is whether or not such fish should be approved for human consumption. The method that the scientists use to engineer the fish is:

1. Scientists duplicate the DNA carrying the genetic information for the growth hormone.

2. The gene is inserted into a circular piece of DNA called a plasmid that can be reproduced inside bacteria.
3. Next, the plasmids are inserted into the bacteria.
4. When the bacteria grow in the laboratory, they produce billions of copies of the plasmid carrying the growth hormone gene.
5. After the copies of the plasmid carrying the growth hormone gene have been produced, they are isolated from the bacteria. The plasmid is then genetically edited, changing its circular structure into a linear bit of DNA. The linear DNA is sometimes called a gene cassette because it contains several sets of genetic material in addition to the growth hormone gene.
6. The gene cassettes are either directly injected or mixed with fertilized fish eggs in such a way that the eggs absorb the DNA, making the cassette a permanent part of the fish's genetic makeup. Since scientists insert the growth hormone gene into the fish's egg, the gene will be present in every cell in the fish's body.
7. The eggs are allowed to hatch, producing a school of fish in which some are genetically changed and others are not.
8. Fish that now carry the growth hormone gene are identified by genetic testing. Fish with the properly integrated gene are used to create a breeding stock of the new, faster-growing variety. (Lewis, 2001).

Bioengineering of fish can be arguably both good and bad. For the fish farmers, the fish can grow big enough to sell in only half the time, which means double the profits. This reduces the time spent growing and taking care of each fish. Less food is needed per pound of fish produced. The chance of losing fish due to death, diseases, and parasites is also lowered since they are growing for a shorter period of time. Since the fish would be cheaper and easier for aquaculturists to raise, they would be a far more inexpensive product for consumers to buy. On the other hand, bioengineering of products also has problems and a lot of critics. One argument against bioengineering is that it is unethical, and animal rights groups such as PETA (People for Ethical Treatment of Animals) believe that we don't have the right to change a fish's DNA. They believe experiments being done on fish, some of which include cloning, are unethical. Religious groups are also against people "playing god," and others believe that the food is unnatural and should not be eaten. Arguments critical of genetic engineering from the scientific community include fears that allergies and other reactions to "engineered" fish may occur. People who normally eat fish might inadvertently buy an engineered fish, and they could have serious allergic reactions. Almost everyone seems to agree that engineered fish should be clearly labeled, and any problems with the fish, such as the increased chance of allergies, should be included on the label. But many more people believe that this is not enough, and more steps should be taken before the fish are produced, or they should not be allowed to be grown at all.

Another argument against bioengineering fish centers around the question of what would happen if the fish get into the wild and mix with natural populations. Animal scientist Bill Muir at Purdue University, "[worries] that transgenic fish escaping from aquaculture facilities into the wild could damage native populations, even to the point of extinction" (FDA, 2002). There are still a lot of studies that are needed on bioengineered fish, but it could be one resource that Costa Rican aquaculture farmers might consider in the future.

With a combination of modern technology, a basic knowledge of pathogens, nutrition, water type, temperature and the right location, aquaculture can be very profitable. Aquaculture can alleviate the strain on natural resources and provide a good source of food and especially protein to the people of Costa Rica.

2.3 Aquaculture and Costa Rican Fisheries

While there are some native Costa Rican freshwater fish which are important to sports fishermen, they have not been heavily targeted by commercial aquaculture ventures. The more important native species for sports fishermen are: bobos, guapotes, tarpon, machacas, snook, and grunts. There have been a few attempts to raise native species for market, such as guapotes, bobos, and machacas; however these have so far failed for various reasons. The guapote is piscivorous, and therefore requires an expensive diet of other fish or food very high in protein. Another major issue is that scientists have not been able to initiate the sexual reversion that is necessary for intensive aquaculture, although

people at Universidad Nacional in Heredia are working on the problem. Sexual reversion is a method of changing the sex of a population of fish, so that they are all the same sex. Reversion is usually done in the early stages of a fishes life. It is done successfully for tilapia, because tilapia are mouth breaders(they raise their fry in their mouth) and because of this the females don't eat while taking care of their children the females don't grow as quickly as the males. Sex reversion is also important for guapote, in which the male can be three times the size of the female (J. Gunter, personal communication, June 24, 2002). The bobo is difficult to breed, and its fry are difficult to raise. The machacas have many small, difficult to remove bones, and therefore there is little market for them (Bussing, 1998).

In 1927, rainbow trout (*Oncorhynchus mykiss*) were introduced to Costa Rica. They are native to colder climates in the western United States and therefore are only suited to the mountainous regions of Costa Rica. They maintain wild breeding populations in only a few upland locations where there are few or no native fish. However, there are now hatcheries run by the Ministry of Agriculture that produce plenty of trout fingerlings for the aquaculturists across the country. Many lodges or roadside stops offer trout fishing, where the consumer pays to catch the fish and has it cooked in a kitchen next to the pond. There are also a number of farmers, generally small-scale, who sell their produce to restaurants and local markets (Nanne, Viquez, & Solano, 2002).

Tilapias (*Tilapia* and *Oreochromis*) are native to the Nile River in Africa but have been introduced into many tropical climates worldwide. Although

intended for pond culture, they have established breeding populations in local rivers and lakes on both the Pacific and Caribbean slopes of Costa Rica. Although they compete with native species for some of the same habitat and food, according to Bussing they have not extensively hurt the local fish, and they are, so far, only found in specific locations (1998). Farming of tilapia is done throughout the warmer areas of the country, in both small and large scale operations. While most of the farms are family run and are simply a pond in the backyard, one large producer in Guanacaste province has over 600 employees. Most of the tilapia raised by this producer are exported as foreign markets are better and there is not a large enough market for the fish in the Costa Rica. A variety of species and hybrids are raised, in order to produce the fastest growing, largest fish. In the first month, the tilapia fry are fed a male hormone mixed with their feed. This produces about 98% males, which helps to control overpopulation and allows the fish to devote their energy to growth rather than reproduction. Another method that has been used to prevent overpopulation is polycultures with the piscivorous guapotes, which eat a certain percentage of the fish and can be harvested themselves (A. Otarola, personal communication, June 20, 2002).

The black bass (*Micropterus salmoides*) has also been introduced in some ponds, but it apparently has not invaded native waters and has not been cultured for the market. Goldfish, guppies, and Mexican platy have also all established themselves in various locations in Costa Rica but do not seem to be causing major problems with local ecosystems, nor are they currently cultivated for sale on a large scale (Bussing, 1998).

2.4 History of the Costa Rican Aquaculture Industry

There are three main types of aquaculture in Costa Rica: tilapia, trout, and shrimp. Only one percent of the country's aquaculture is devoted to other species, mainly shellfish. However, our project focuses on the freshwater aquaculture industry, so only tilapia and trout will be discussed.

As mentioned above, trout were introduced to the highlands of Costa Rica in 1927, however, they were not intensely cultivated for a long time. After the Second World War, tilapia were introduced to Costa Rica, as well as in more than 65 countries around the world. These were raised extensively (at a low density), mainly for subsistence farming. Often mixed-cultures were employed using pigs, ducks, or cattle to fertilize the lakes, since tilapia feed on the plants that would benefit from the additional nutrients. Also polycultures were used, meaning that other species of fish were raised alongside the tilapia (Guzman, Hernandez, and Quesada, 1999, pp. 12-13).

In 1965 and 1966, the Instituto Interamericano de Ciencias Agrícolas and the Centro de Diversificación Agrícola de Turrialba began the first organized effort to bring aquaculture into Costa Rica. They arranged the import of Oreochromis mossambicus and O. aureus and helped some small aquaculturists in the area get started. In 1974 the Departamento de Acuicultura was created, under the Ministerio de Agricultura, to promote aquaculture at a national level. They brought in new species of tilapia including O. hornorum, O. niloticus, red tilapia, and gilt tilapia. In the 1980's, Tilapia nilotica were introduced to Costa Rica for

commercial cultivation, in the first intensive effort at aquaculture. The technology was borrowed from Israel and utilized tanks with recirculated water to maintain a high density of fish. In 1994, under law number 7384, the Instituto Costarricense de Pesca y Acuacultura (INCOPESCA) was created with a mission to: coordinate the fishing and aquaculture sectors, promote and organize ocean fishing, manage marine game and aquaculture, promote conservation and the sustainable use of oceanic and aquacultural resources, and make rational use of fishing and aquaculture products (see Appendix A). Since then, aquaculture in Costa Rica has grown rapidly, with many trout ponds springing up in the mountains, as well as much growth in small tilapia farms both for sale in local and foreign markets.

There are now two major private commercial tilapia aquaculture businesses in Costa Rica. The first and oldest (established in 1986) is Aquacorporación S.A., located in Cañas, Guanacaste, with over 600 employees. They produce 4,200 metric tons of O. niloticus in the form of fresh fillets for export to the U.S. This accounts for about 25% of Costa Rica's total national fish production. The second corporation, established in 1995 and located in Limón, is Acua-Caribe S.A. with 11 hectares of tanks. Their produce is also shipped to international markets. Both of these businesses are transnational businesses with foreign investors.

In 1997, TILACOOP R.L. was founded by aquaculturists in the region of San Carlos. They are a co-op of farmers who have developed ways to diversify aquaculture and help solve problems related to: commercialization, technical

assistance, supply of fingerlings, access to credit, and the processing of tilapia to raise their value. Another co-op, Coopehuetarnorte R.L. produces 24 metric tons per year, all destined for international markets. Independent tilapia farmers produce a total of 15 metric tons per year. As of 1999, 70% of the tilapia aquaculturists were associated with some co-op. Out of the total population of aquaculturists, 60% rely on aquaculture alone for their livelihood, and it is the most profitable sector of most polyculture farms(farms with aquaculture and some other type of agriculture raised together) (Eugenio, Chacon, & Vega, 1999).

2.5 Costa Rican Aquaculture Statistics

Costa Rica's aquaculture industry consists of three main species: tilapia, trout, and shrimp. There are 796 aquaculture farms in Costa Rica and all but one produce either tilapia, shrimp, or trout. The other farm produces the local fish guapote. Of these farms, 719 produce tilapia or trout. The following chart shows the breakdown of percentages by species of the farms in Costa Rica.

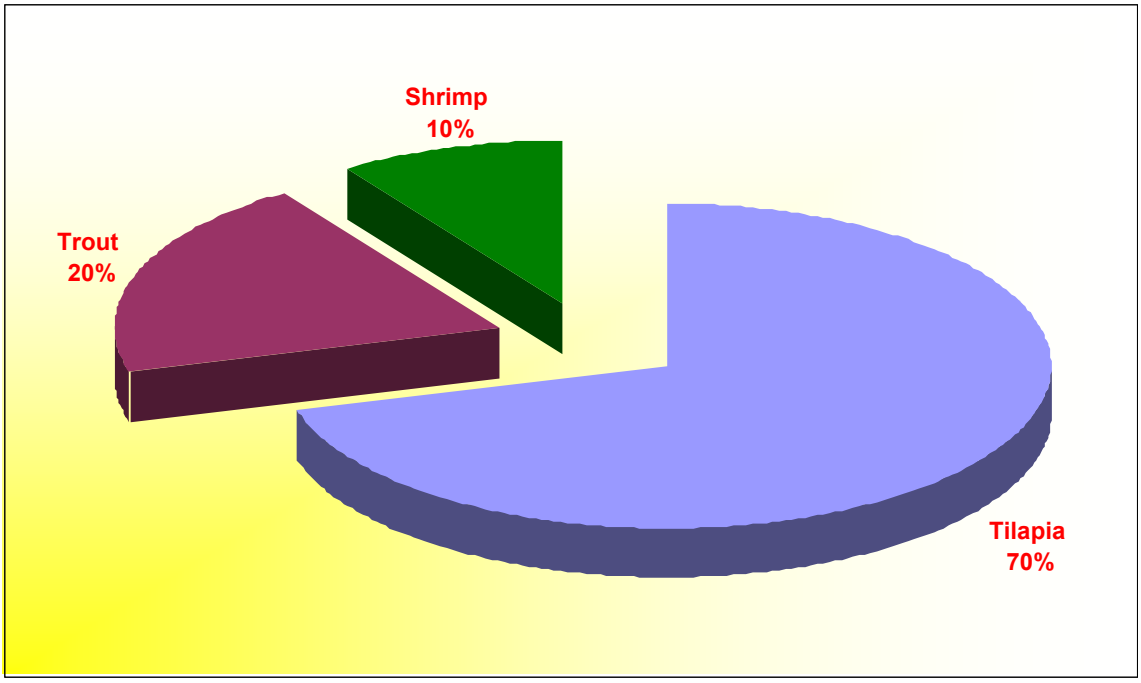

Figure 2.1: Aquaculture Species in Costa Rica by Farms: 2001 (INCOPESCA, 2002)

As shown in Figure 2.1 above, tilapia cultivation is the largest percentage of aquaculture production in Costa Rica, with 560 farms, accounting for 70 percent of the aquaculture farms in the country. The next largest number of aquaculture farms raise trout. There are 159 trout farms in Costa Rica, which is 20 percent of all aquaculture farms. The other type of aquaculture farm in Costa Rica is raising shrimp, accounting for 10 percent of the aquaculture farms, some 76 farms within the country.

Tilapia production also generates the most fish by weight of the three species raised in Costa Rica. Shrimp farmers produce the second largest amount of product, followed by trout farmers who produce the smallest amount. Figure

2.2 displays the statistical output of these three species along with the output of other aquacultural species produced in Costa Rica.

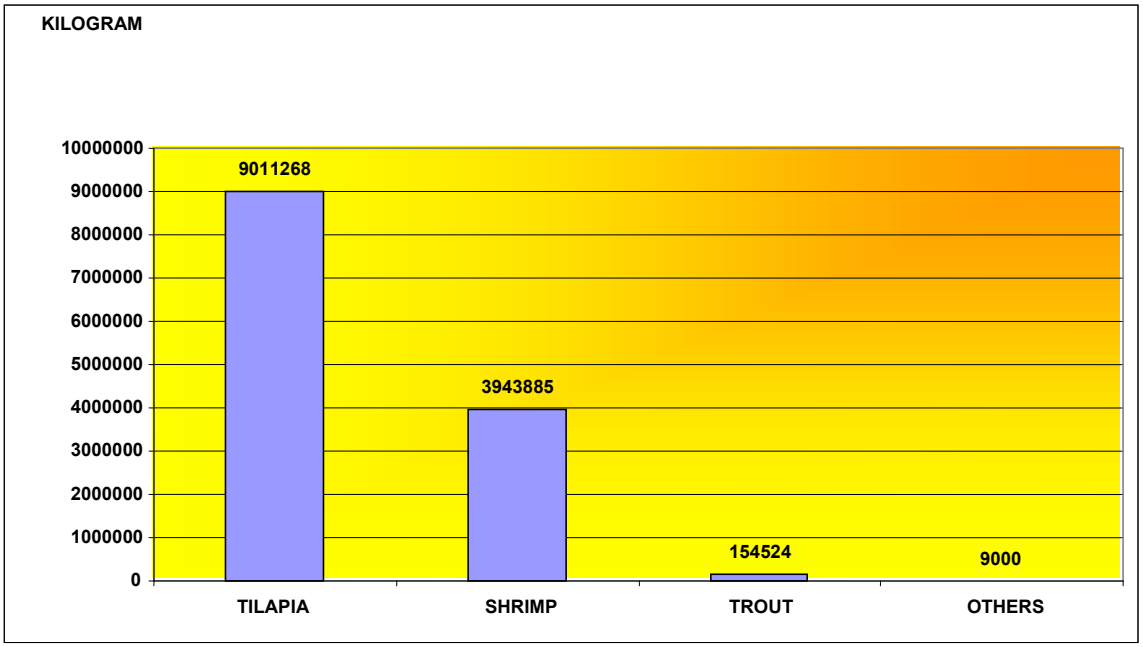

Figure 2.2: Total Aquaculture Production in Costa Rica in Kilograms: 2001 (INCOPESCA, 2002)

The typical amounts of tilapia produced, in kilograms, are shown in the next figure, as an example of the sizes of most tilapia farms.

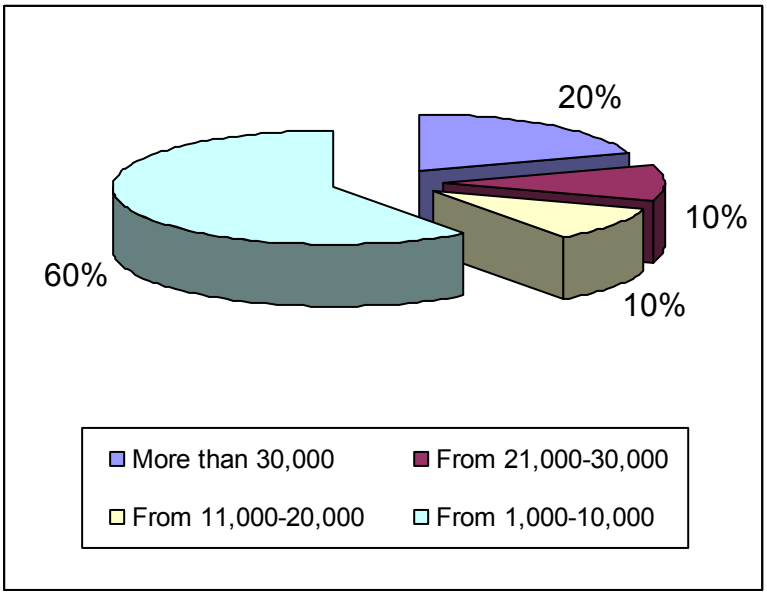

Figure 2.3: Kilograms of Tilapia Produced by Percentage of Farms: 1999 (Reproduced from Eugenio, Chacon, & Vega, 1999)

Figure 2.4 shows a breakdown of the types of species cultivated, in Zona Norte, in the San Carlos area.

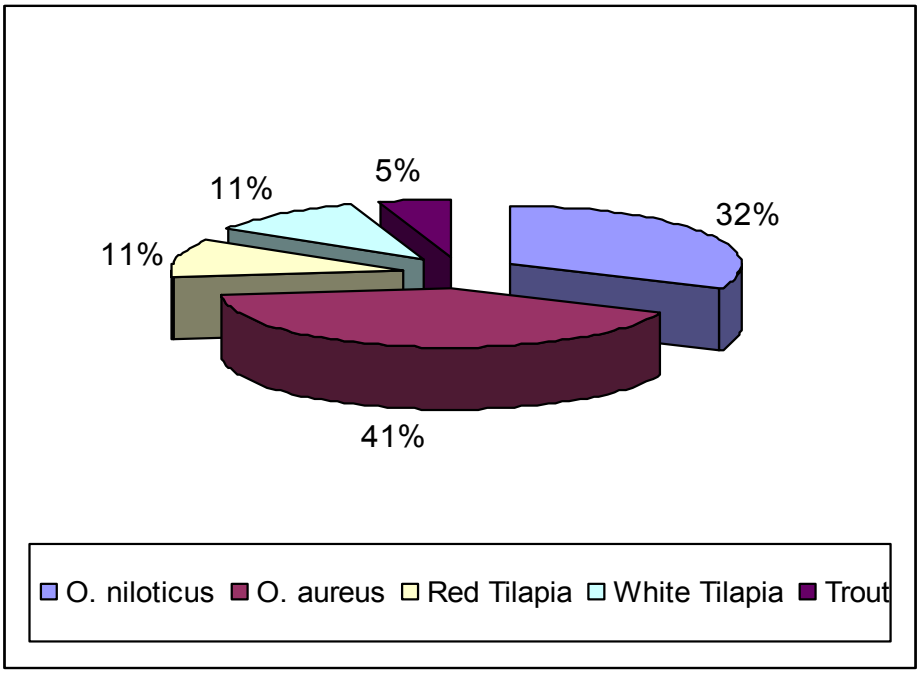

Figure 2.4: Species of Fish Raised in Zona Norte: 1999 (Reproduced from Eugenio, Chacon, & Vega, 1999)

2.6 Aquaculture Market Statistics

In 1990, Vargas estimated a market demand for tilapia of 550 metric tons per year within Costa Rica; the United States market (where much of the tilapia is exported) was estimated at 5,000 metric tons (1994). The following two figures show the demand in the U.S. for fresh tilapia fillets from Costa Rica, in 1998. Thirteen percent of the U.S. imports of tilapia are for fresh fillets, and 62% of U.S. imports of fresh tilapia fillets are from Costa Rica.

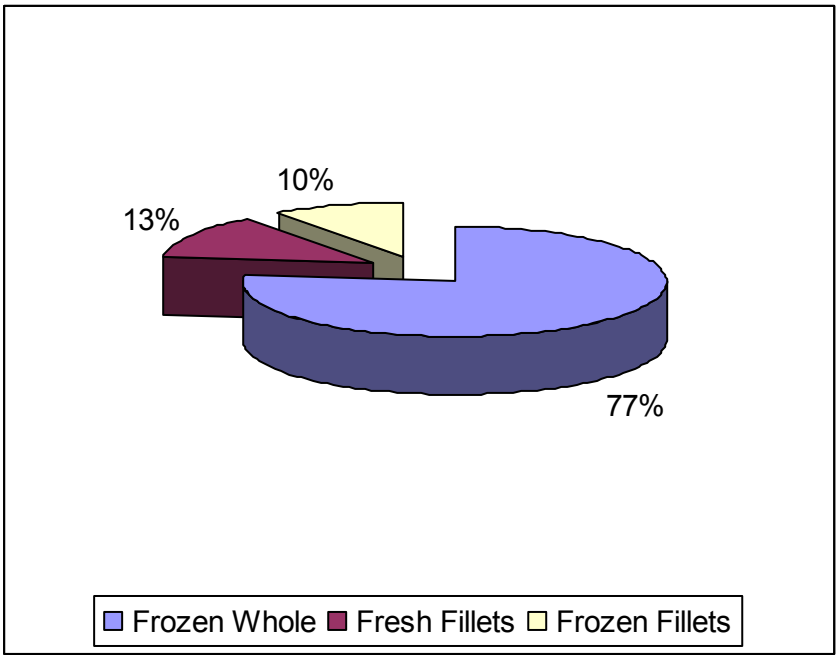

Figure 2.5: Tilapia Imports by the U.S. in 1998 (Reproduced from Eugenio, Chacon, & Vega, 1999)

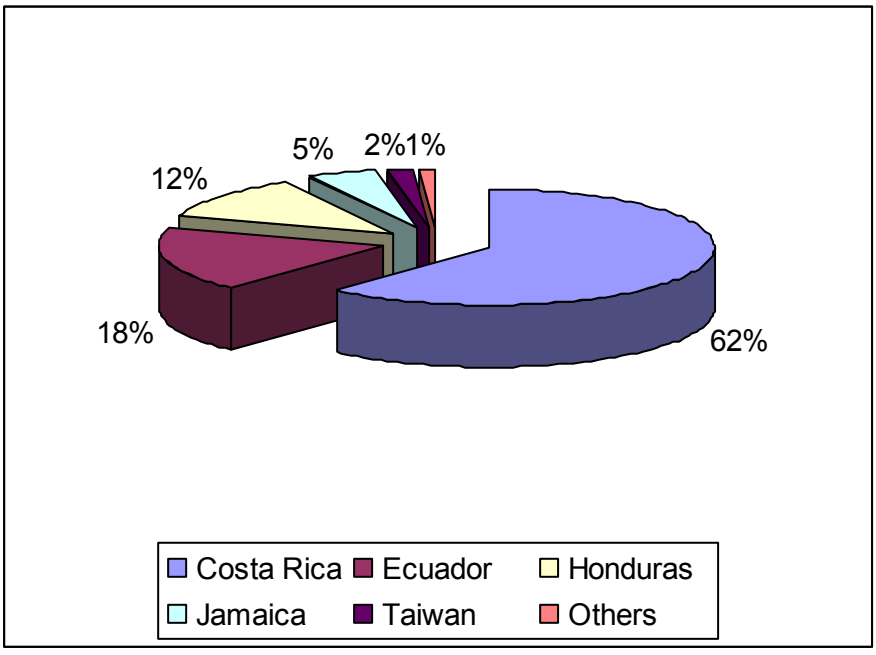

Figure 2.6: Sources of Fresh Tilapia Fillets imported by the U.S. in 1998 (Reproduced from Eugenio, Chacon, & Vega, 1999)

Although Costa Ricans do not eat a large amount of fish, tilapia is well accepted and found in most grocery stores and fish markets. The varieties most consumed are Oreochromis aureus and O. niloticus. In 1990 the San José metropolitan area consumed 435 metric tons of tilapia, 36% of the total demand in the country. Eighty percent of the metropolitan demand was for fillets. In 1990, for whole O. aureus, aquaculturists received 180 colones per kilogram, for fish between 300-350 grams apiece for the season of April-June. In May of 1998, the principle market for tilapia in New York City (USA) fetched a price of $9.05 per kilogram of fillet. The price for frozen fillets imported from Ecuador was $6.05 per kilogram during the same time period (Eugenio, Chacon, & Vega, 1999).

2.7 Costa Rican Government

Costa Rica is an excellent model of democracy and has a history of peaceful international relations, while maintaining a society that is relatively homogeneous compared with other under-developed countries. This is especially notable when compared to the political instability and economic stratification of the neighboring Central American countries (Biesanz et al., 1999, p.92). However, all governments are in some manner disorganized in their bureaucracy, and most are inefficient compared to the private sector; Costa Rica's government is no exception. Costa Rica's civil service is going through a major reorganization, just as the country is experiencing major changes in its economy. Establishing a training program for INCOPESCA employees required consideration of issues of accountability and review.

According to Ching (2001, pp. 37-8), a Costa Rican government official's position is typically immune from competition and employment insecurity. Unlike the private sector, he or she would thus not necessarily be held as rigidly accountable for decisions as individuals in private businesses. Ching believes that the Costa Rican government has historically been an enormous, centralized, politically appointed, inefficient bureaucracy. He believes that a new human resource management model needs to be developed to hold employees accountable and to increase efficiency in the system. According to Ching (2001, p.42), to do this the following issues need to be addressed in Costa Rica to increase efficiency: there needs to be a commitment to investigate and fight corruption; labor agreements should focus on increasing administrative effectiveness; decentralization should occur by assigning employees efficiency; and there must be reorganization and retraining based on public policy objectives. To increase the accountability of employees the following points need to be established: performance based and time-limited contracts need to be used; salary should be determined by performance; and team-based organization needs to be utilized.

INCOPESCA as a government agency, of course shares some of these problems of efficiency, policy review, and assessment of employee performance. Especially when setting up an infrastructure for aquacultural education and retraining of fish farmers. Therefore, the program that we propose should include regular assessment of the effectiveness of extension agents and whether farmers are receiving accurate and useful information from INCOPESCA. The design and

utilization of institutional structures must also make the education of farmers feasible and desirable for the rural aquaculturists, whom the program specifically targets.

2.8 Costa Rican Development

Although many large multinational companies (maquiladoras) are eager to establish themselves in developing countries to utilize inexpensive labor, and while some foreign governments encourage them for the jobs and income they bring, according to Kraemer (2001, pp. 815-20), they are often not the best means for a country to develop industrially and to modernize. He believes these maquiladoras do not provide any long-term sustainable employment opportunities for the local citizens, since they often bring in their own management personnel, do not invest in the local economy, export their profits, push around the local authorities, and often exploit their workers through low wages, unhealthy or dangerous working conditions, sex discrimination, and repression of collective organization. There are exceptions to the norm, of course, and often large businesses can attract a whole industry to an area, and apparently this is the case with Intel in Costa Rica. Intel provides, "generous pay and stock options for workers, and standards of efficiency and safety that are emulated by local businesses" (Carl, 2000). This has helped Costa Rica to move into high-tech production, which carries many high wage benefits.

An alternative to maquiladoras is the microenterprise. These are small, locally owned businesses whose goods and services stay within the local

economy. According to Kraemer (2001, pp. 821-2), these types of organizations are typically much more egalitarian, ethical, and provide long-term sustainable development for the country and the workers. They also will not disrupt the local culture and customs as most large corporations would. These businesses are often not recognized or promoted by the government, which may leave them at a disadvantage in competing against larger, subsidized corporations. However, some financial institutions, non-profit organizations and international development institutions have supported these microenterprises in developing countries.

Another problem that is part of the globalization dilemma is the proposed Free Trade Area of the Americas (FTAA), which plans to enforce free trade among all nations of the Western hemisphere, except Cuba (MUNUC, 2001). This could allow U.S. and other large multinational companies to move into developing countries such as Costa Rica and exploit cheap labor, tax breaks, and weak environmental and labor laws. A major argument against the extension of NAFTA is that the negotiations could be conducted in secret, hidden from the public and even elected representatives through Fast Track executive decisions. If the U.S. Congress passes Fast Track procedures, they agree to have no power in changing the final FTAA proposal, and only a limited amount of time for debate. Congress would only be given the power to vote "yes or no" on the proposal (Multinational Monitor, 2001, Editorial). On the other hand, the members of the FTAA committee contend that this policy includes adequate provisions to prevent

environmental and labor exploitation, and that democratic principles govern their proceedings (SICE, 2002).

An example of the problems that can arise from the globalization of aquaculture is shrimp farming. Shrimp farming is done mainly in developing countries in Southeast Asia, Central America and South America. However, the shrimp are mostly exported to industrialized countries, often at a loss to the local environments. Ecologically essential mangrove forests are common victims of the global shrimp mariculture industry. If environmental protection is not explicitly included and enforced by the FTAA, it is likely that more forests will be bulldozed for unsustainable types of aquaculture (Greenpeace, 2002). The negative effects of globalization, including the exploitation of local workers and degradation of local environments, suggest the advantages of microenterprises such as tilapia and trout farming as currently practiced in Costa Rica.

2.9 Education in Costa Rica:

As well as issues concerning development, Costa Rica's educational levels are important to understand for our project. Costa Rica is a small country, around the size of West Virginia, located in Central America. It is approximately 51,100 sq km with around 4 million inhabitants (CIA, 2001, The World Factbook 2001: Costa Rica). Costa Rica's population is mostly in the central valley, around the capital of San José, which has a population of over one million. The country does not have an army, and instead uses a significant amount of its resources on public education. This shows how highly Costa Ricans believe in the value of education.

Although the level of education in Costa Rica is not as high as in some parts of Europe and North America, it recently has been on the rise. The Handbook of World Education details the growth of the Costa Rican education system, which began with the adoption of a "plan of development" in 1972 (Wickremasinghe, 1992, p. 193). The handbook goes on to say that between 1978 and 1982 the regionalization of education was promoted in order to increase the efficiency of the system. It states that this progress in education involved local communities, raising the consciousness of the population about education and resulting in improved educational quality in Costa Rica. Beginning in 1986 through the present, in an effort to further raise the quality of education, computers were introduced in schools. Emphasis was placed on the sciences, and achievement tests were put in place to measure performance.

Despite these efforts to improve the quality of education in Costa Rica, there are still problems that restrict the educational system. The Handbook of World Education notes that the effectiveness of the Costa Rican school system is low, resulting in a high percentage of students dropping out of school. Biesanz, et al. (1999, p. 199) state that the average Costa Rican adult had only finished 5.7 years of primary school through the 1990s. In spite of this, the Central Intelligence Agency lists Costa Rica's literacy rate at 94.8 percent (CIA, 2001). This rate is very high compared to other Central American countries. Another problem presented by The Handbook of World Education is that the curriculum in place in Costa Rica is still inadequate, because it does not meet the needs of rural areas. The current curriculum, with the exception of technical schools, does not

prepare or allow students to pursue opportunities other than going on to higher education for the attainment of a college degree. This problem has caused a deficit of appropriately educated workers, who are needed for the economy to prosper. Therefore, rural workers often need to be trained in their tasks on-the-job. The aquaculturists under study in this project, in fact, do not have the training that they need to run their businesses, unless they are directly taught by other aquaculturists.

Another problem with the education system is there is not an equal distribution of educational opportunities in Costa Rica because of social stratification (Wickremasinghe, 1992, p. 194). The Handbook of World Education points out that a student's social status can limit his or her access to the educational system as well as success in it. This is caused by inequalities in the regional distribution of educational facilities at all levels of the system. This, in turn, promotes regional inequality (Wickremasinghe, 1992, p. 194). Costa Rica currently invests 6 percent of its Gross Domestic Production (GDP) in education. Zaida Sanchez, the deputy minister of education in Costa Rica, states that this number needs to be increased to 6.7 percent to cover all of today's needs (Munoz, 2001**)**. This lack of financial resources has played a factor in promoting inequalities in the regional distribution of educational facilities but has also caused another problem – lack of teachers. There is a very high demand for teachers because of the call for improved education and an increase in the student population. To add to this problem, Costa Rica does not have a national teacher training system, resulting in 41 percent of the country's primary schools, mostly in

rural areas, having just one teacher for all grade levels. The problem is also evident in secondary schools, where 19 percent of the teachers do not have college degrees (Munoz, 2001). Because not enough money is spent on education, teachers are extremely underpaid and undertrained, making the profession undesirable for most people.

2.10 Types of education

As discussed above, the education system in Costa Rica is still lacking in some ways, especially in rural areas, due to low levels of funding and unequal distribution of educational opportunities. Such inequities in education lead to the assumption that many of the rural aquaculturists are in need of academic instruction in aquaculture. However, the Costa Rican aquaculturists possess invaluable practical experience and knowledge pertinent to their trade, perhaps making formal academic training less important.

Alternative means of education may help extension agents teach specific aquaculture techniques. The following definitions describe various types of education (Dumitrescu, 1999, II. Explanatory Memorandum by Mr. Dumitrescu). Education is defined, "as a lifelong process, which enables the continuous development of a person's capabilities as an individual and as a member of society, [which] can take three forms:

> Formal education -- the structured educational system usually provided or supported by the state, chronologically graded and running from primary to tertiary institutions;

> Informal education -- learning that goes on in daily life and can be received from daily experience, such as from family, friends, peer groups, the media and other influences in a person's environment;

and Non-formal education -- educational activity which is not structured and takes place outside the formal system.

The difference between informal and non-formal education mainly lies in the fact that informal education is involuntary and passive, while non-formal is voluntary and active (Dumitrescu, 1999, II. Explanatory Memorandum by Mr Dumitrescu).

The following table from The Encyclopedia of Informal Education (Smith, 2001) contrasts formal and non-formal education programs.

Table 2.9: Formal vs Non-formal Education

	Formal	Non-formal
Purposes	Long-term & general Credential-based	Short-term & specific Non-credential-based
Timing	Long cycle / preparatory / full-time	Short cycle / recurrent / part-time
Content	Standardized / input centered Academic Entry requirements determine clientele	Individualized / output centered Practical Clientele determine entry requirements
Delivery system	Institution-based, isolated from environment. Rigidly structured, teacher-centered and resource intensive	Environment-based, community related. Flexible, learner-centered and resource saving
Control	External / hierarchical	Self-governing / democratic

2.11 Education in the Workplace:

Around the world, education is used to increase employee performance in the workplace. This can be accomplished by informal education gained from work experience, an informal job-specific training program conducted by another worker or professional trainer, or a formal job-specific training program conducted by an educational institution (The Yearbook Committee and Associated Authors, 1985).

Different types of education can also be used together to reinforce the information being learned and to make the learning process more effective. Ramey-Gassert's (1997, p. 442) study of informal science environments (based on the effectiveness of children learning science concepts during visits to museums and zoos) shows that children who have *formal* science education in the classroom, reinforced with *informal* science education, retain the information better than children who were just taught with *formal* science education. She argues that this is due to the fact that *informal* education allows the children to have control over their learning. This means the learning is at their own pace, they can discuss the material with fellow classmates, and they can physically participate in the learning activities, rather than the learning being just a mental activity.

The mixing of educational practices can be effective in the workplace also. Stephen Billett (2000, p. 272) investigates whether guided workplace learning can

assist the development of skills and knowledge required for workplace performance. He studies engagement in authentic workplace activities, and the direct and indirect guidance available in everyday participation in the workplace. Billett concludes from his studies that, "engagement in everyday activities in the workplace provides ongoing access to goal-directed activities and support that are instrumental in assisting individuals constructing or learning new work-related knowledge as well as strengthening of that learning" (Billett, 2000, p. 273).

However, Billett acknowledges that this type of learning may not be enough for a worker to become an expert at his or her work (Billett, 2000, p. 273). The need for conceptual knowledge or understanding is one reason for this, as experience may not be enough for the worker to fully understand his or her tasks. There can also be negative outcomes from learning through everyday practices. Workers may learn incorrect concepts or procedures that can endanger themselves or limit their performance. Billett shows that direct guidance, along with learning through everyday practices, will help overcome bad practices and misguided conceptions. Direct guidance, from a more experienced worker, will strengthen conceptual knowledge, help the worker develop the procedural capacity to complete his or her tasks, and guard against inappropriate procedures and concepts (Billett, 2000, p. 273). We will return to this notion of peer instruction, using more experienced aquaculturists to train newcomers, later in this report. By combining different types of educational methods, worker performance at all levels can be improved.

2.12 Formal Aquaculture Education in the United States

In the United States, most aquaculture education is conducted through formal channels. Typically an aquaculturist obtains a Bachelors of Science degree in fisheries (or a similar discipline) from a college or university. For higher-level management positions, they may acquire a masters or doctoral degree. For entry-level aquaculture technicians, a B.S. degree is not required. The technicians may hold an Associates Degree, but often they have only taken a few college level courses and have obtained much of their knowledge from on-the-job training and through individual practical experience. Therefore, one goal of such organizations as The National Council for Agricultural Education is to increase the number of aquaculture students and programs for aquaculture in universities (The Council, 2000). However, some believe that this type of education is impractical for real-life aquacultural practice. In one survey of the U.S. catfish culture industry, only 16 of 51 fish farmers employed anyone with a college degree (Brown, 1995, p. 15).

Aquaculture does not simply rely on scientific knowledge but also involves many economic and business features. Since the faculty of most universities tend to impart mostly academic information, the students are well prepared to pursue graduate degrees, veterinary medicine, or become fisheries biologists. Unfortunately, these programs are not entirely suitable for aquacultural practitioners, since the business aspects of aquaculture, economics and management, are as important as the underlying science. Brown (1995, p. 16) believes that there is a need for U.S. aquaculture education to reflect the realities

of the industry by incorporating management and marketing training in the curriculum, and this should certainly be a component of training for Costa Rican aquaculturists. U.S. community and technical colleges currently offer aquaculture technician programs covering: mechanics, welding, small engine repair, hydraulics and construction. Brown believes that although this is good training for technicians, this is unnecessary for an aquaculture bachelors degree and should be kept out of the curriculum.

2.13 Non-formal Aquaculture Education in the United States

There are non-traditional programs for aquaculture education that are much more suited to the industry's needs and can provide better hands-on experience but do not result in a degree. The Aquaculture Division at Harbor Branch Oceanographic Institution (ACTED) in Ft. Pierce, Florida, is supported by funds from the Federal government to boost economic development after the recent collapse of many shellfisheries and the ban on net fishing (Davis-Hodgkins, 1999, p. 31). Former fishermen were trained to grow shellfish and received clam seed and a lease site at the end of their yearlong training program. Harbor Branch is very effective at training both experienced and new aquaculturists, as well as the support people who work alongside aquaculturists. Since the center is located within the 60-acre Aquaculture Development Park, the school is linked to many private businesses and to the research staff onsite. This provides an excellent atmosphere for the students to make connections and be

involved in practical learning. Also, ACTED provides workshops and longer courses that can be customized for individuals, organizations, college groups, or businesses, even internationally. As an example, when a group of owners and employees of a Mexican clam farm came to ACTED in 1998, they were given a practical course in the ACTED hatchery and nursery and also visited a nearby commercial farm (Davis-Hodgkins, 1999, p. 32).

ACTED is located in a commercial setting, and the courses are taught by research and production staff, which ensures that the information will be state of the art. The program focuses on the participants' specific topic of interest and utilizes the particular systems for their chosen species. Unfortunately, the resources at ACTED are probably not possible to replicate in Costa Rica, due to limited amounts of aquacultural experience and economic resources here. While some of the larger aquaculturists may be able to visit ACTED to train, it is unlikely that most of the small rural operations would be able to utilize these facilities. As Bruner says, "a first step in educational assistance is to create the resources and machinery for long-range educational assistance, including finances, material, institutions, and personnel" (1966, p. 61). Therefore, it is reasonable to look into other, less resource intensive, methods of aquaculture training.

2.14 Informal Educational Methods

Informal education consists of several basic topics, organizing learners individually, organizing learners in groups, and organizing learners into communities. As well as there being different ways to organize learners, there are also many different ways to present information. Each method of organization and presentation has its pros and cons, and all of them cover a variety of different situations differently.

2.14.1 Organizing Learners Individually

The first method of organizing learners individually is *self-directed study*. Self-directed study consists of "learning efforts that are initiated and directed by the individual." The individual can decide when and how to use the information on their own at his or her convenience. The strengths of this method are that it contributes to the ultimate goal of learning in that it is done continuously throughout life. It is also good because a person feels satisfied that they accomplished the learning individually. Also since it is done on their own time, they can anticipate what they want to learn in a given day and plan their time accordingly. Lastly it gives the individual the advantage of choosing the time, place, and situation under which they learn. Leaving the study up to the individual allows for a much freer learning experience, making it much more attractive for people already working full time. However, letting someone decide when and where he or she wants to learn can have bad effects as well the most important

being that since the learner is left entirely to him or herself, he/she can easily get discouraged or distracted and stop the learning process. Another problem is that without someone else to compare themselves too and since it is on their own it is hard for the learners to evaluate exactly how much the studying has taught them and it is hard to decide if the learning has been useful, giving them another excuse to stop their self-education.

Another method, slightly similar to self-directed study is *prepackaged learning*, in this type of informal education, the teacher plans a lesson in the form of a video or cassette, and teaches over the radio or other media, or passes out information to be looked over. However, the teacher and learner still do not talk one-on-one to asses the progress that the learner is making or discuss problems the student may be having. This has some of the same advantages as self-directed study, in that the learners get to choose the time, place, and circumstances that they study under but it is a much more formal lesson plan. This gives flexibility to the learner, but allows for a well structured lesson plan with important information. Other advantages are that the student gets to pick what way the information is presented, whether it is a movie, tape, CD, or other form. As long as there is a preprogrammed lesson on different types of media, the students can choose whichever one is easiest for them to use. Some problems with prepackaged learning are that it is not case specific. A general lesson is made and everyone who chooses learns the material. The lesson cannot be changed and could be either too general, or too specific for different cases. Another problem is

that, like self-directed learning, the students have very little or no contact with the teacher, so any questions that they have may remain unanswered.

A form of independent study that is a hybrid between preprogrammed learning and independent study is *correspondence study*. In correspondence study the learner conducts independent study, supplemented by a prepackaged lesson plan developed by a teacher, followed by occasional visits by the teacher to both supervise the learning process and answer any questions the student may have. The advantages of this type of learning are that it can still be done on the student's own time, however the visits by the instructor ensure that the student has actually accomplished the learning. Although the prepackaged material may be broad or general, the supplemental independent learning can be focused on whatever the students feel that they need more information about, and occasional visits by the teacher can answer any specific questions that the students could not find answers to on their own. Like prepackaged learning and independent study, this is a fairly inexpensive way for a limited number of teachers to teach and evaluate a relatively large amount of students. The problems with this type of learning are that it can take up a lot of the student's time, between the independent study, reading or listening to the prepackaged information, and meeting with the teacher. Also communication between the teacher and student can slowly break down, leading to a collapse of the program. Like most forms of independent study, there can be a lack of motivation to continue the studying on the part of the student.

The last two forms of learning as an individual are different from the first three in that they are very personal and depend on a one-on-one relationship between the student and the teacher.

The first form is either *apprenticeship* or *internship*. The only difference between apprenticeship and internship is in the definitions of the words. An intern is preparing for a profession and an apprentice is preparing to master a craft. This method uses the teacher as a model for the student. The student learns by both observing the teacher and participating in the activity being taught with the teacher. Internship and apprenticeship are a very hands-on way to learn. The instruction can be anywhere from a couple of days to a year or more of instruction, depending on how intensive the activity is. The advantages of this program are that it is a very in-depth, one-on-one education, and it can cover all aspects of a profession or craft. Another advantage is that it is hands on, the student can see the problems and methods of the job or craft in person and see the solutions to the problems, even taking part in the solving them. Under the supervision of the person teaching them the skills, they can be sure that the information is learned and retained and that the students will be able to carry it out on their own in the future. The main problem with this method is that the student may be told how to solve a problem, but not why the solution works. Also, there may not be enough time for the students to see all aspects of a skill and may not see solutions to all problems that they run into, or may see solutions but not be able to transfer them to solve their own problems. Other problems that may arise have more to do with the conditions the student and teacher are living

under. If both the teacher and student are poor, the teacher may not be able to pay the student for time spent as an intern. In this case, the student may not be able to take enough time away from work to be able to fully learn the skill. There can also be problems with the student-teacher relationship in that the teacher may be younger or considered less important in the community than the teacher, and therefore the student may feel bitter about being taught by someone in a "lower class" than themselves. The teacher may also be intimidated by the student's status. A large problem with this is that it is a one-on-one method, meaning that there needs to be as many teachers as students. Alternately students may need to wait a long time for a teacher to have free time to teach them.

The second form of one-on-one training is *tutoring*. Tutoring relies on a close relationship between student and teacher. This is the ideal learning situation for most adults. Tutoring is very effective as long as the teacher has a good background in the area being taught. Advantages of tutoring are that the lesson can easily be adjusted to meet specific student's demands. Depending on the availability of the teacher and student, it can be done on a fairly flexible schedule. It allows the teacher an opportunity to analyze the best methods to use to instruct each student. If the student doesn't respond to one method, the teacher can adjust the next lesson and use another method. It also allows the teacher to closely monitor what is being taught and change it for each individual case. Disadvantages include cost, number of teachers required and quality of teachers. The student can also become dependent on the instructor, and although they may

have a good knowledge of the subject, they may not know how to apply the knowledge on their own (Seaman, D. F., & Fellenz, R. A., 1989).

2.14.2 Organizing Learners as Groups

Seaman and Fellenz argue that, **"**Group learning can be very effective because not only do the students learn from the teacher but also learn from each other. After group learning the students can continue to help each other instead of always going back to the teacher" (1989).

One way to organize learners in groups is with *action groups*. An action group is a band of people brought together to solve a problem, who learn and adapt through the process of solving it. This way of learning is constantly showing the group members the effects of change. It also focuses on teaching them to do an in-depth study of an issue and apply what they have learned. The effectiveness of a group as a learning device is usually based on the effectiveness of their solution to the problem. The advantages of action groups are that through the accomplishment of tasks it not only teaches a lot of material and problem-solving strategies, but also that learning is helpful and makes the student want to learn more. This method also helps students learn to communicate better with other people. Also, since it is group learning, it is harder for the entire group to get discouraged or off-track and end the learning all together than if it is one person learning on his/her own. The problems with this method are that accomplishing the goal can become more important than the actual learning process, leaving the student with a lot to still learn. As in all groups, group

problems can occur causing a breakdown in the learning process. Also, if the solution to the problem is not effective, or if the group cannot find a solution at all then they can get discouraged with this kind of learning.

A *club* is a group of people with similar interests that meets to discuss their interests. It is not specifically formed for the purpose of learning, but learning is often associated or integrated into the club. Often learning is done by talking to and observing other members of the club, but an outside teacher can be brought in on occasion to present material to the group and teach everyone new information. The advantages of this method are that a lot of clubs are usually formed by people who want to learn more about a subject. There is a sense of unity in the club, where people will not want to stop going to meetings or stop the learning process. Using the knowledge of everyone in a club, members can study all aspects of an activity, and learn from other members who have more experience in different activities. Clubs can also work together to solve a common problem or to meet a common need. Some problems with clubs are that members may want to focus on the primary goals of the club and not on learning. Rituals and requirements of the club may have a bad impact on the learning process, and the actual conditions the club meets under, location and social conditions, may not be conducive to learning. But overall clubs are excellent places for people with common learning goals in the same field to learn from one another.

Much like in a club, in a *learning team* students learn primarily from each other with occasional guidance from an outside person. Learning teams are generally composed of a small number of people who get together to study a

subject. Unlike clubs, learning teams focus solely on actually acquiring knowledge and not on other aspects that clubs may focus on. A learning team also does have one set "teacher" figure that generally provides the guidelines for education to take place and organizes the lessons. However, like in a club learning is still done primarily from other members of the group. Advantages of a learning team are that the students think through a problem and practice teaching or explaining it to each other and, in the process of explaining it, they learn it better themselves. With only a few members they support each other in the learning process, and, unlike in a club or a large group where members can compete against each other, everyone works together. However, the closeness of a group can have bad effects on the learning process as well. The goals of the members could be too different for any effective learning to take place, or one person with different goals could change the focus of the entire team. Also, since the team members are learning on their own, it can take a lot more time and work to find solutions to problems that could be resolved easily by a teacher or explained easily in a lesson plan.

A *workshop* develops specific skills in the students or teaches them to solve a common problem. In a workshop many students get together to be trained in a certain area. There is a teacher who presents the lesson, usually in the form of examples or models. Workshops can be one or two hours or last up to several weeks. They can be at a student's home, or be in a training facility. The teachers choose the best location based on what are the best conditions for delivering their lecture. The advantages of a workshop are that it can bring together a lot of

students to be shown a lesson. In a workshop the students get to see examples of what they are trying to learn. It is a very hands-on way to learn a subject. Disadvantages are that it is hard for the teacher to be sure that all students are paying attention, and it is also hard to monitor all students to be sure that they are participating. Also, workshops take a lot of planning and sometimes can cost a lot of money for the teacher. If a teacher does not have enough time or money to properly organize a workshop, it can be ineffective, and students will not want to take the time to come back for another lesson.

The simplest methods of group training are *courses*. A course is a lesson taught by a teacher at a specific location and time. Generally a course is based on a series of lectures by the teacher with some examples, and the students come to take notes and learn. This method is most like formal education except that it can be done at night, in the evenings or during weekends, whenever the most students will be able to attend. Advantages of a course include a set schedule and lesson plan, meaning that the student can decide which courses to attend and which ones are not as important to go to. However, courses can become impersonal, depending on the number of people who attend. They also cannot be tailored to the individual student.

Large Group Presentations affect the quality of education by decreasing the amount of participation, but they increase the number of people being educated. Large group presentations are an easy way to get a lot of general information out to a lot of people. Such presentations can be very effective depending on how well the material is presented. Good teachers with a lot of

teaching aids can teach a large group of students very effectively (Seaman, D. F., & Fellenz, R. A., 1989).

2.14.3 Organizing Learners as Communities

Like organizing learners as individuals or groups, organizing them as *learning communities* can have its advantages. If students see what they are doing as a community effort, they can become very motivated and feel like their efforts are helping the good of the whole community. However, individual goals and ideas can be lost on the community. The needs of each individual person cannot possibly be met when a few teachers are trying to educate an entire community. When organizing students in a community, they can work together to study common problems and find solutions. This idea is very much like a club. Essentially the students form an association, but unlike a club which focuses only on its members or limited problems, their learning focuses on larger more community-based problems (Seaman, D. F., & Fellenz, R. A., 1989).

2.14.4 Presentation Strategies

As well as different methods for organizing education, there are many ways to present that information. The following techniques detail some of these strategies.

LECTURE – prepared oral presentation.

SYMPOSIUM- series of short presentations by 2 to 5 people speaking on various topics of a related subject

DEMONSTRATION- Presentation prepared by the instructor to show some aspect of a topic. The demonstration usually contains visual aids along with instruction by the teacher.

SIMULATION GAMES – A teacher makes a useful or workable model of some aspect of a topic so that learners can analyze it from all different viewpoints (Seaman, D. F., & Fellenz, R. A., 1989).

2.14.5 Interaction Strategies

DISCUSSIONS – During a discussion a group of people comes together to talk over a problem. Everyone in the group shares his or her own different and individual knowledge, viewpoints, and opinions on the same subject, and they all make a more informed decision.

PARTICIPATION TRAINING – Students learn by having discussions on a topic, then reflecting on the topic afterwards. In the case of aquaculturists they can all discuss how they market their fish and afterwards reflect on what they learned during the conversation. Participation learning can be very important because very often aquaculturists will have conversations about aquaculture and they will need to pick out the most important points of the conversation.

FISHBOWL – Group members observe one another and how each person reacts to a similar problem so that they can learn several solutions and pick the best one.

BUZZ GROUPS – A facilitator presents a topic and then small groups of participants attempt the find the best ways to address the topic brought up.

BRAINSTORMING – A technique used to determine all areas of a topic that needs to be covered. It is effective when making a lesson plan for the aquaculturists and also to determine the best way to present the information (Seaman, D. F., & Fellenz, R. A., 1989).

2.14.6 Evaluations

After education has been completed, it is very important to analyze the learning that has taken place. This provides information on both the effectiveness of the training program and the knowledge of the students, and it is important to evaluate both.

EVALUATE TEACHERS - An evaluation of the teaching methods, the material taught and the actual teachers should be done on a regular basis to determine if the methods and teachers involved are actually effective. An evaluation is also good to see how the students react to different teachers and different material.

EVALUATE WHAT HAS BEEN LEARNED/TAUGHT – This is one of the most important parts of the process. If an extension agent spends an extended period of time teaching a subject, it is important to know if the aquaculturists learned and absorbed the information. It is necessary to periodically test the knowledge of the aquaculturists to determine what should be taught to them next and whether the extension agents need to review materiel or not (Seaman, D. F., & Fellenz, R. A., 1989).

2.15 Distance Education in Developing Countries

Another method of non-formal instruction that has worked with primary and secondary education throughout the world is *distance education*. This method allows information to be dispersed to rural and low technology areas at a reasonable cost. Since less developed countries (LDC) lack much of the technological infrastructure and resources that developed countries (DC) have, many forms of distance education are not feasible. The Internet, television, and often telephone capabilities are limited in LDCs, including Costa Rica. Eastmond (2000, p. 100) points out that 75% of all phone lines are in 10 DCs, that Italy has more lines than all of Latin America, and that only 1% of all Latin Americans have access to the Internet. However, this does not mean that LDCs cannot provide effective distance education. Print (through postal services), audio (radio and tapes), videocassettes, and sometimes television are all methods of disseminating distance education. Often, distance education is the only choice for LDC students, who have other family or employment responsibilities that they cannot afford to neglect. For success in a distance education program, social and cultural issues, faculty training, different learning styles, and international collaboration should all be considered in the curriculum. As in all education, the content and support provided to students are the most important factors; technology is not (Eastmond, 2000, pp. 101-105).

An often-overlooked factor in distance learning is the accuracy of the information, since there is a lack of current resources and ability to study abroad.

Therefore, in LDCs, much of the information may be outdated. Distance education must be used efficiently to reduce costs. Using the appropriate media, utilizing established organizations, and adapting local needs and labor to the imported models of distance education will provide a good starting point for any cost-effective, non-formal training program, for aquaculture (Eastmond, 2000, pp. 105-110). Successful experiments in technology-aided distance education have already been conducted in Costa Rica. One study used a series of video lessons accompanied by printed manuals and a facilitator to educate rural farmers. The experience was very beneficial to the farmers and was only 1/3 to 1/5 of the cost of traditional extension activities (Balit & Masias, 1996). Costa Rica also has a large distance education university, Universidad Estatal a Distancia (UNED), with an enrollment of 12,863 in 1999 (Eastmond, 2000, p. 104). This institution, located in San José, was established in 1977 by the Costa Rican government to facilitate higher education in agriculture and for the working population. It offers various degrees including Agrarian Administration, Elementary Teaching, and Banking and Financial Administration at a technical level or at four degree levels (AA, Bachelors, Licenture, and Masters) (iCDL, 2002). This institution could help INCOPESCA to distribute information about aquaculture. Also, INCOPESCA could assist UNED by working with them to develop an aquaculture degree program, in which rural campesinos would gain proficiency in aquacultural techniques while continuing to run their farms. Currently such a partnership does not exist, but if such a program were developed, it could take

much of the workload off of the limited number of INCOPESCA extension agents.

Chapter 3: Methodology

3.1 Preparation

In preparing this project we have researched aquaculture technology and methods of aquaculture, training programs, and education in developing countries. We have interviewed experts in aquaculture and aquaculture education. Lastly, we have identified possible organizations that could share information and collaborate with INCOPESCA field agents in Costa Rica to help train the aquaculturists. This information is compiled in the literature review section of this project report. The methodology section details the procedures we used in Costa Rica to obtain Costa Rica specific information and how we developed our final recommendations for a training program.

3.2 Determining Existing State of Aquaculture in Costa Rica

Our project objective was to develop a training program for INCOPESCA's extension agents and to further develop aquaculture in Costa Rica by suggesting more efficient methods for the aquaculturists to educate themselves. To achieve this objective it was necessary for us to determine the existing state of aquaculture in Costa Rica. The first step in determining this information was to familiarize ourselves with our sponsoring organization (INCOPESCA) and Costa Rican culture, specifically educational methods and aquacultural practices. To familiarize ourselves with our organization, we began by talking with our advisor, Álvaro Otarola. In our first meeting he clarified the

previously mentioned project focus and gave us a spreadsheet containing all 796 aquaculture sites in Costa Rica. This also contained a breakdown of the number of farms raising each species, and annual production numbers for each species. Álvaro Otarola also put us in contact with 10 INCOPESCA extension agents to survey and interview. We used the snowball sampling method for identifying other relevant people to interview.

To gather additional information on the present state of aquaculture in the country we used archival research. The University of Costa Rica library and INCOPESCA archives were useful in obtaining specific information about Costa Rican aquaculture that we were not able to get in the U.S. From INCOPESCA's records and our surveys we learned: educational levels of employees, their current training protocols, what technologies or methods they do and do not have, and how the agents interact with farmers. Statistics were readily available on the number of practicing aquaculturists in Costa Rica, their farm locations, and the different methods they use and species they raise. In addition we obtained their yearly production levels, and the markets to which they sell.

From the spreadsheet containing 719 tilapia and trout farms, we created a list of the sites that we wanted to survey, interview, and observe. The sites were chosen to be representative of the different types of sites in Costa Rica. To do this, we selected one farm of each type, (super-intensive, intensive, semi-intensive, and extensive) of each species, (tilapia or trout) in each province except Limon (Puntarenas, Guanacaste, San José, Heredia, Cartago, and Alajuela). We attempted to group the sites that we wished to visit as close together as possible,

within each province, to simplify our trips. We ended up with a total of 35 sites, which we wanted to survey. However, Mr. Otarola informed us that his extension agents could distribute our questionnaires for us, and we could accompany him on a couple trips to the major trout and tilapia production areas to conduct our interviews. In total, we received 40 questionnaires, 16 from trout farmers and 24 from tilapia farmers. We conducted five informal interviews with aquaculturists, and observed six aquaculture sites. While archival research was still very helpful, it was not our main method of gathering data in Costa Rica.

3.3 Evaluating the Aquaculturists' Viewpoints and Knowledge

Before we made any suggestions to INCOPESCA about the best formula for training its extension agents, we needed to listen to the ideas of the other half of the equation, the aquaculturists themselves. We used a survey of fish farmers to gather a large amount of quantitative data on Costa Rican aquaculture, which provided a more accurate picture of the overall status of the industry. However, the survey also included many qualitative questions concerning the aquaculturists' relationships with INCOPESCA and opinions about the state of aquaculture in Costa Rica. The responses to our questions provided us with original suggestions and gave us a more accurate view of the needs of the aquaculturists. The aquaculturists were chosen from a list that we created from INCOPESCA's records of all the aquaculture farms in the country. We created a stratified sample that represented the various types and locations of farmers including 40

aquaculturists in all, which was as thorough as possible given our time constraints.

The purpose of the survey was to determine the extent of knowledge about aquaculture of the small-scale farmers as well as to learn their opinions about the problems with aquaculture in Costa Rica, how aquaculturists view INCOPESCA agents, and what they believe the agents need to do better, or know more about, to be helpful. The resulting information allowed us to look at the issues from the farmers' viewpoints and gave us insight into what techniques and knowledge the aquaculturists would like to learn from INCOPESCA. We finalized the survey questionnaire in English in the second week, after getting advice from our liaison, Álvaro Otarola. In the third week we translated the questionnaire into Spanish, again getting advice from Álvaro on the translation. We began to pass the questionnaires out that same week. Our liaison and advisors reviewed and approved our questionnaires (only the English version by our advisors) to determine the clarity of the questions and to ensure that our results would be quantifiable. Half (22) of the questionnaires, after revision, were given to INCOPESCA extension agents to be distributed to trout farmers over the next few days. We picked the responses up the following week and recorded the results. So that we could obtain quick results that could be analyzed as soon as possible, we conducted some of the survey in person immediately and then translated and logged in the results the next day. The other half (24) of the questionnaires were distributed two weeks later to tilapia farmers and collected and analyzed the week

after that. The English and Spanish versions of the questionnaire are located in Appendix C.

3.4 Assessing INCOPESCA Agents' Experience, Viewpoints, and Knowledge

We surveyed both the aquaculturists themselves and the INCOPESCA extension agents to discover how both groups viewed their relationship. The survey of INCOPESCA agents focused more on their knowledge, what methods they want to be trained in, and their opinions on means to improve aquaculture. The extension agent questionnaire is located in Appendix D. This questionnaire was also translated into Spanish, and was delivered either in person or by INCOPESCA staff to the extension agents. As in the aquaculturist survey, the translations were reviewed by our liaison, and our advisors examined the English version of our questionnaire for clarity and utility prior to its distribution.

3.5 Gathering Creative Information on Aquaculture

Surveys gather information from a broad range of people but are not as effective at obtaining in-depth information. They are limited in their questions and only provide limited responses. The type of information that we needed to make recommendations to INCOPESCA required in-depth understanding and creative brainstorming between us and the people involved. We needed information on aquaculture techniques, technology, and common educational methods, Costa Rican culture, and numerous other factors that concern aquaculture education. To gather this information, we conducted interviews.

Interviews were particularly beneficial because Ticos prefer face-to-face contact. We interviewed as many knowledgeable people as possible who had information pertaining to our project. These included one American aquaculturist, five Costa Rican aquaculturists (both large and small), one aquaculture educator, three INCOPESCA extension agents, an INCOPESCA manager, and a fisheries biologist from Worcester Polytechnic Institute. We chose our interviewees mainly by convenience and snowball sampling. In most cases, there was some difficulty communicating effectively, since we have limited Spanish-speaking abilities, and most of our interviewees knew little or no English.

The interview questions were often similar to those on the survey questionnaires but varied depending on the individuals and their specialties. While conducting the interviews, we also asked some questions specifically related to the daily activities of the aquaculturist (or whoever was being interviewed), to get a better sense of the details of their profession. For all people we included a few general questions, however, including: Are INCOPESCA agents providing the knowledge and assistance that are required by aquaculturists? What new technologies or farming methods do you think would be useful for aquaculturists to know? This method allowed us to determine opinions and other in-depth qualitative information. Often connected with the interviews we observed aquaculture techniques and INCOPESCA agents' interactions with farmers.

3.6 Observing Communication between Field Agents and the Farmers

We toured six aquaculture farms and hatcheries, both large and small scale, for both tilapia and trout. The owners were willing to allow us to observe their farming methods and the resources that they use to raise the fish. Most of these tours were given at the same time as our interviews and while questionnaires were completed. These sites were chosen by convenience, rather than from a random selection of all aquaculture farms. However, we attempted to view a sample of the different types and sizes of operations. Since many of the trout farms are located in the mountains south of Cartago, and the majority of the small tilapia farms are in the Ciudad Quesada (or San Carlos) area, these two locations were chosen so we would be able to see the largest number of farms in the least amount of time. Álvaro Otarola drove us to the trout farm locations, and arranged for an extension agent to show us some of the sites in San Carlos. Since we could not see every farm, we attempted to view an accurate representation of the different types and sizes of operations. We chose to visit four sites of different sizes around San Gerardo de Dota, south of Cartago, where many of the trout farms are located, and we visited two tilapia projects in the San Carlos area. We accompanied and observed some INCOPESCA field agents when they went to farms and interacted with farmers. From these observations we were able to gain a clearer and more accurate picture of how INCOPESCA agents communicate with and assist farmers. If the agents had been unrealistic in their perceptions of the abilities of the farmers, or if the two parties were not

communicating well, this could only have been discovered through such direct observation.

3.7 Assessing the Market

One of the major problems that many of the aquaculturists that we surveyed seemed to have was the marketing of their fish. The science of aquaculture is only one part of running an aquaculture business. We wanted to determine how much farmers were selling their fish for, to whom, and what factors determined those prices. To accomplish this we decided to create a questionnaire of a few simple questions concerning the prices of tilapia and trout at fish markets, supermarkets, and restaurants. We attempted to conduct our survey over the phone, but the respondents had difficulty understanding our questions, or were unwilling to participate in the survey. As a result we decided to conduct informal interviews at a few locations that would hopefully represent the bulk of the market. Since there is competition among stores, we felt that if we completed our questionnaire at one or two markets of each category, (supermarket, restaurant, or fish market) they could be used to represent the responses of the whole category. Therefore, we decided to interview staff at Mas X Menos, AutoMercado, a fish market, and a restaurant. The questionnaire (located in Appendix E) that we followed in our interviews included items such as: How much do you charge per kilogram for tilapia or trout? How much do you buy your fish for? From whom do you purchase your fish (aquaculturists, or a middleman)? How much of each species do you sell per year? From these

questions we hoped to determine if there is a major price discrepancy between what the farmers are paid and what the fish are being sold to the consumer for. We were also interested in where the farmers are selling their products, and how they could improve their profits through a more organized marketing strategy.

3.8 Comparing Costa Rican Aquaculture to Other Countries:

To determine whether or not Costa Rican aquaculture can be improved, we needed to obtain some numerical evidence, rather than simply the opinions of people. To do this, we researched how aquaculture is done in the United States, other countries, and what scientists consider to be the best practices. Comparing aquaculture in different countries with diverse climates, resources, and cultures is not an easy task. However, we were able to determine a number of factors that could be objectively compared. Since 70% of aquaculturists' operation costs are for the fish food, the price and quality are of utmost importance to the farmers. We compared the ingredients of Costa Rican feed manufacturers to those in the United States, and to what scientific articles declared to be the best. We also compared the average production of fish in the U.S. and Costa Rica, to see if Costa Rican aquaculture could be improved.

3.9 Analyzing the Results:

After we completed our data collection, using the described methods, the data were compiled and analyzed to develop a plan for a training program that takes into account all parties and issues involved. We used content analysis to

evaluate the data from the qualitative questions on our surveys. From this we deduced the important areas that the aquaculturists wanted training in, and how they felt INCOPESCA could improve its services. From the extension agents we determined what areas they desired training in, and their opinions on the obstacles to aquaculture in Costa Rica. Knowing the opinions of the farmers and agents, as well as the ideas of educators, we developed a plan for a training program for INCOPESCA employees, along with recommendations on how they should transmit their knowledge to the aquaculturists.

3.10 Developing the Training Program:

Once we had determined the important problems with aquaculture in Costa Rica, and what areas INCOPESCA could improve in, we needed to propose a solution. To maximize the efficiency of INCOPESCA's extension agents, we created a program through which the aquaculturists can receive assistance and training from other, more experienced, aquaculturists. This involved the extension agents training leader farmers, and the leader farmers training other farmers. From our knowledge of the educational levels of the aquaculturists, we determined that the best method of education would be non-formal techniques. We researched these methods, and came up with a list of different techniques that could apply to different situations. The methods are described in the Background/Literature Review, and our specific suggestions are in the Recommendations section. We also created a list of sources for the extension agents to use to further educate themselves, and to keep up with the most current

aquacultural research, this list is located in Appendix H. The Recommendations chapter of this report details the issues which we determined to be the most important for the aquaculturists and agents to be trained in.

Chapter 4: Results/Analysis of Results

Throughout our entire project we obtained results, in the form of responses to surveys, interviews, and archival research. In trying to make sense of these results, several underlying themes became apparent. These themes are that the aquaculturists feel that they are not getting enough visits from INCOPESCA extension agents and that the visits that they get do not provide enough training in aquaculture, both on the raising of the fish and their sale and marketing. We have found several reasons for these problems; however the principle difficulty is that there are only 10 extension agents but 719 farms to support. INCOPESCA is also running on a limited budget with a limited amount of equipment, including shortages in water testing devices and gasoline for their four-wheel drive vehicles. In the following paragraphs we will present an analysis of the results we have obtained from our research.

4.1 Knowledge and Attitudes of Aquaculturists

Based on our survey of sixteen trout farmers, we found that: two farms used extensive systems, four were semi-intensive, and eight were intensive. None of the farmers surveyed exports his trout, indicating that at this moment trout only has a domestic market. From our survey of twenty-four tilapia farmers: we found that seven used semi-intensive systems, five used intensive systems, and the other twelve farmers misunderstood the question. None of these farmers exports his tilapia, however one indicated that he was planning on doing so.

Farmers generally had only a primary school education, through the sixth grade. Specifically, nine farmers indicated having had more than six years of schooling, twenty-seven replied "primary," (6 years) and four answers were not quantifiable. This means that most of the farmers have not taken any biology classes, have not studied fish physiology, and probably have not had any formal schooling in how to run a business. Since the aquaculturists have not received much formal education, and because of their businesses they do not have the time to, formal methods of education would not be effective means for INCOPESCA to instruct the aquaculturists.

Although their formal educational backgrounds were similar in that, very few farmers had more than a primary school education, they do have a wide range of experience in aquaculture. Three farmers had over 20 years of experience, while the rest had less than ten years, and some had only 1 or 2 years of experience. This means that most of the aquaculturists' knowledge had been gained through informal, on-the-job training. It is likely that non-formal and informal methods of training similar to the ones that the farmers are used to will be the most effective for them, and we have designed our training program with this in mind.

All of the respondents felt that INCOPESCA was helpful and useful in their methods of assisting aquaculturists. The majority of the aquaculturists (82.5%) had no trouble communicating with INCOPESCA. All of those who said there were problems mentioned difficulty with telephones, as an issue. Many aquaculture farms do not have access to telephones and some of INCOPESCA's

stations do not have them, so it can be difficult for aquaculturists to contact the agency. Therefore, there does not appear to be a communication problem between the extension agents and the aquaculturists in terms of language and style, but logistical problems, such as not having telephones, are issues.

All forty of the surveyed farmers agreed that the introduction of new fish species to Costa Rica would be beneficial to aquaculture, but only four of the respondents noted that environmental effects should be taken into account. Five farmers specifically mentioned a desire to see the introduction of more cold water fish (such as salmon) to Costa Rica. Since these farmers raise trout and tilapia, introduced species, it is understandable that they would approve of the practice of introduced species, as their livelihood derives from such imported varieties. The introduction of salmon, catfish, or other species to Costa Rica has potential economic benefits as it may allow these farmers to tap into larger international markets and to diversify their aquaculture production. For this reason, the farmers see great potential in new species. However, such an endeavor would require a lot of research in new technologies and markets before it could be deemed feasible. Even then, there is the problem that the new fish would undoubtedly escape into the wild eventually and could potentially cause damage to native species or ecosystems.

Most of the farmers commented that the aquacultural technology and equipment in Costa Rica was not sufficiently up-to-date, and that this should be improved. Specifically, respondents said that only what INCOPESCA provided

was available, and they needed more nets, fish and egg size selectors, and water quality gauges.

We asked a number of qualitative questions that were designed to determine the areas of aquaculture that the farmers thought presented problems, what INCOPESCA could do to help, and how the extension agents could improve in their assistance. We received a variety of responses, mostly in the form of short, one sentence answers, but some common themes stood out. It was difficult to determine categories, since each response was different and this was made especially difficult by poor handwriting, poor spelling, and the language barrier. However, the technique resulted in quantifiable data about what issues the aquaculturists felt were most important.

The important needs that stood out are food, equipment, training, markets/marketing, and visits. One question asked what is required to conduct aquaculture in Costa Rica. As you can see in Figure 4.1 below, eight trout aquaculturists responded that marketing was the area that was most important for their businesses, followed by six for training, four for food and equipment, and two for INCOPESCA visits. One trout aquaculturist stated that the regular supply of fry was a problem, but marketing and training were also included in that particular farmer's set of concerns.

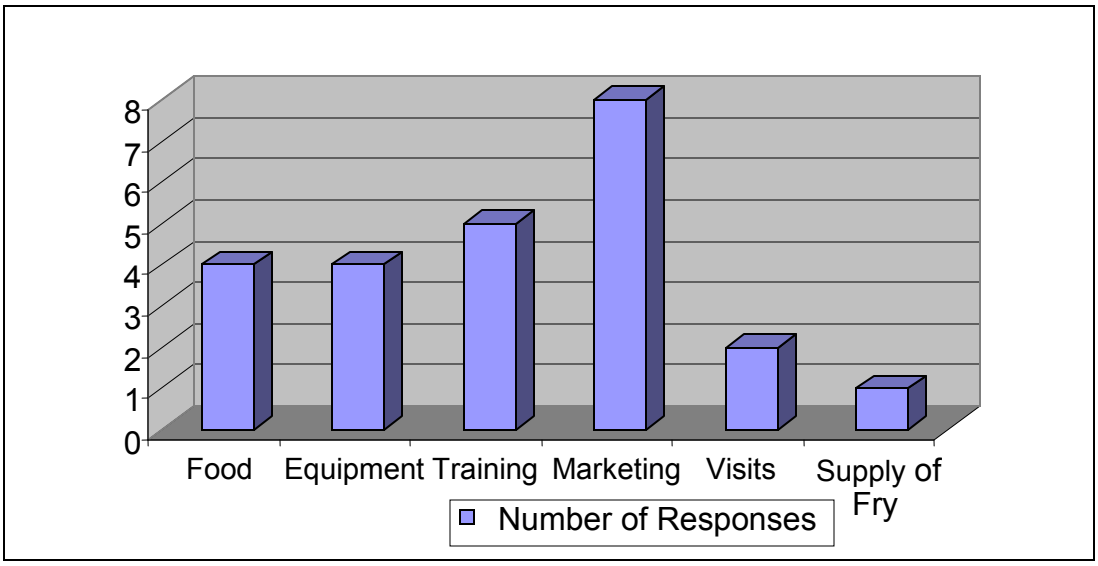

Figure 4.1: What Trout Farmers Feel are Important to their Businesses

While all of these factors are vital for conducting aquaculture, the frequency that each item was mentioned indicates how many farmers feel that the item is important. If many farmers feel that an item is of crucial concern, then the item is very important or is not receiving enough attention. Overall, for the trout farmers, marketing is the most important requirement that they need assistance with. Marketing information should therefore be a high priority for INCOPESCA when training the trout aquaculturists. Under marketing, farmers specifically wanted: promotion of the produce, external markets, and more profitable prices. No specific topics were asked for with regard to training, but equipment to check the physical chemical characteristics (pH, O_2, temperature) of the water were mentioned twice. The farmers also stated that they needed better fish food at lower prices, more accessible credit, and lower interest loans.

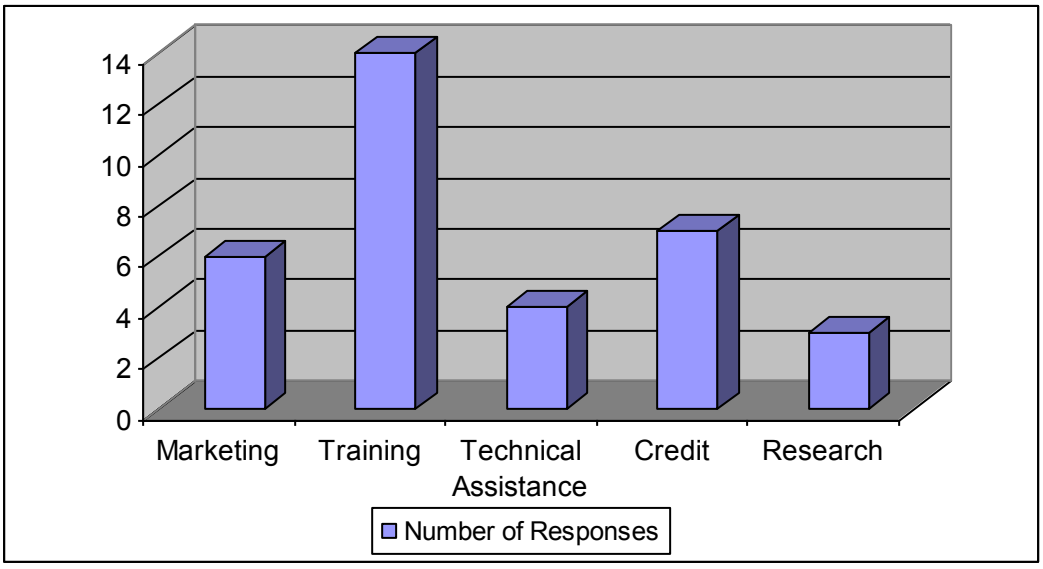

Figure 4.2: What Tilapia Farmers feel are Important to their Businesses

In Figure 4.2 above, the same question was asked of tilapia farmers, but there were different responses. For tilapia farmers, training (with 14 responses) was by far the most important requirement, with credit second and marketing only third. This is possibly explained by the fact that many of the tilapia farmers are part of a co-op which helps them market and distribute their products, while the trout farmers do not have one. The tilapia farmers primarily requested training, the only specific subject mentioned was diseases, although aquaculture manuals were requested. More accessible credit, and lower interest loans were asked for as well as larger and more stable markets. For research, the farmers wanted better methods of sex inversion, and better quality of fry. Technical assistance was listed as necessary by four respondents; hopefully the problem can be alleviated with better education. However, training was listed as the most important issue, which indicates that a training program would be of significant benefit to the tilapia farmers.

The same common responses could be seen in the answers to question 15, which asked what INCOPESCA can do to better help aquaculturists. As you can see in Figures 4.3 and 4.4, the same themes of equipment, training, and marketing dominated the answers. More visits were also listed as important by both types of farmers. Although the need for training was stated the most (13 of the 53 responses), marketing, equipment (trucks, gas, water testing systems, fish and egg size selectors, and nets), and visits were also specified as important for INCOPESCA to provide. One respondent asked for aquaculture equipment to be sold without taxes to aquaculturists. Markets for exportation of their fish and some market analysis were requested.

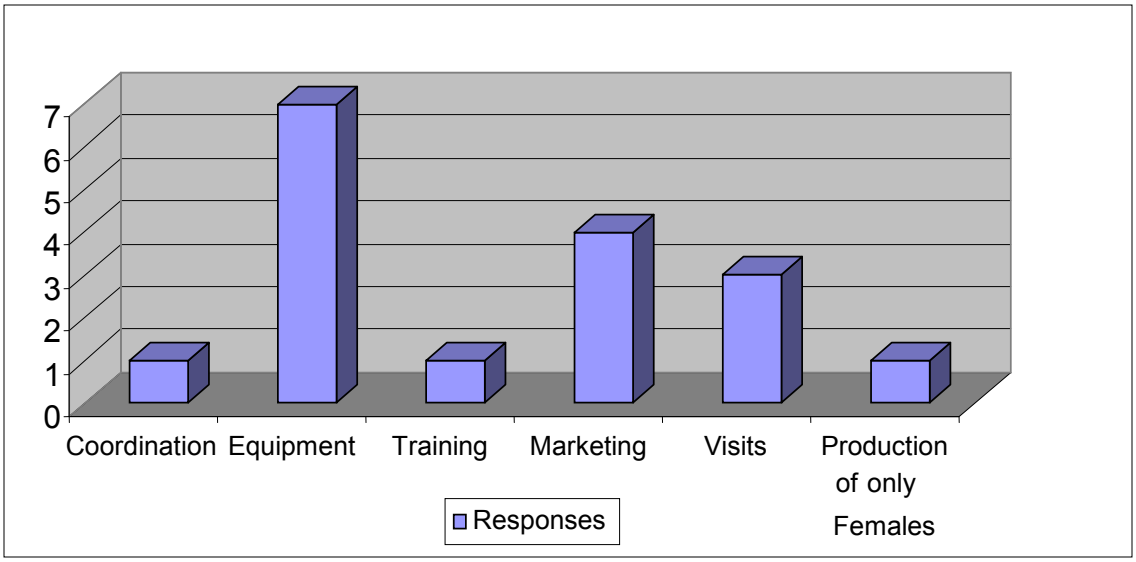

Figure 4.3: What Should INCOPESCA Provide to Trout Farmers?

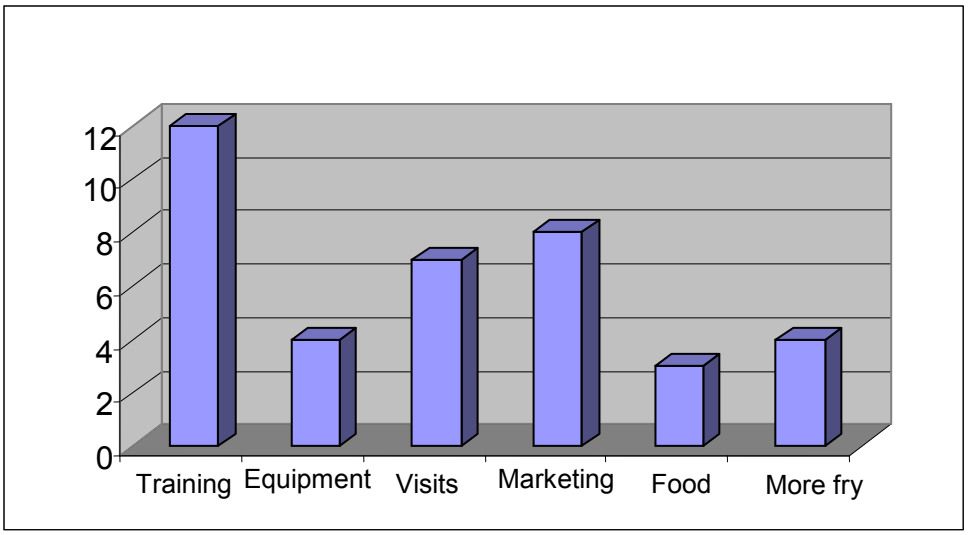

Figure 4.4: What Should INCOPESCA Provide to Tilapia Farmers?

In Question 13, in our survey, we asked whether the farmers thought that INCOPESCA agents have the knowledge needed to help the fish farmers carry out their aquaculture business. Eleven of the 16 trout farmers responded with a yes. All but one of the twenty-four of the tilapia respondents agreed. The five trout farmers who responded no (as well as some of the yes respondents from both parties) indicated areas in which the agents need to improve. These are: training the aquaculturists, providing them with equipment, visiting more often, and helping them with marketing (see Figure 4.5). Eight stated that they need better training methods, two said equipment, one requested more visits, and one mentioned marketing. The specific areas that the farmers wished the agents were better trained in are: pathology of fish, methods and new techniques of cultivation, and refresher courses for the agents to keep their knowledge up to date. Again, water pH, O_2, and temperature meters were requested.

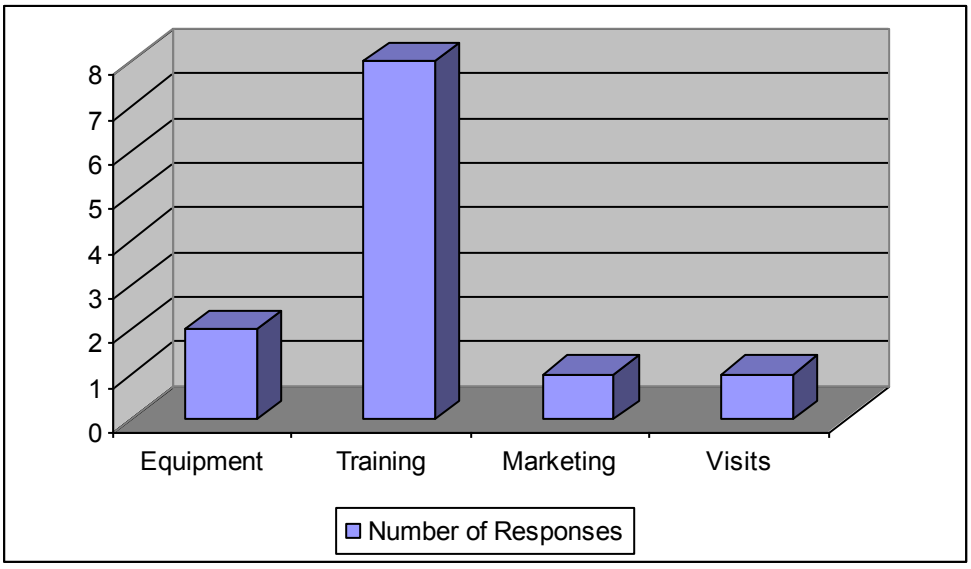

Figure 4.5: Areas Needing Improvement from Agents

4.2 Experience and Attitudes of the Extension Agents

One extension agent has 10 years of experience, while all others had at least 20. All of the agents feel that their experience is at least sufficient to carry out their job. All agents have a bachelors degree and some have licensure and masters degrees. The agents had degrees in: biology, pathology of fish, and aquaculture.

An extension agent's job consists of giving technical assistance, overseeing construction of tanks, and showing aquaculturists how to take water samples; some agents also provide aquaculturists with the fry for cultivation.

Most extension agents agree that the aquaculturists need better marketing and product promotion. There is also a lack of training for aquaculturists and agents, and the technology available to the small farmers is substandard compared to other, more developed countries. When asked if INCOPESCA has enough

extension agents, all of them said that it does not. They also stated that at least 10 more agents are needed. All extension agents feel that they are helping the aquaculturists.

4.3 Communication between Field Agents and the Farmers

During our observations of some of the tilapia and trout farms, and from talking to agents and aquaculturists on the farms, we found that the greatest obstacle to communication between aquaculturists and INCOPESCA extension agents is the isolation of the farms and the physical difficulty of communicating with these areas. Telephones are often not available and are unreliable. The extension agents often do not have four-wheel drive vehicles or enough fuel to visit the farms as regularly as many of the farmers want.

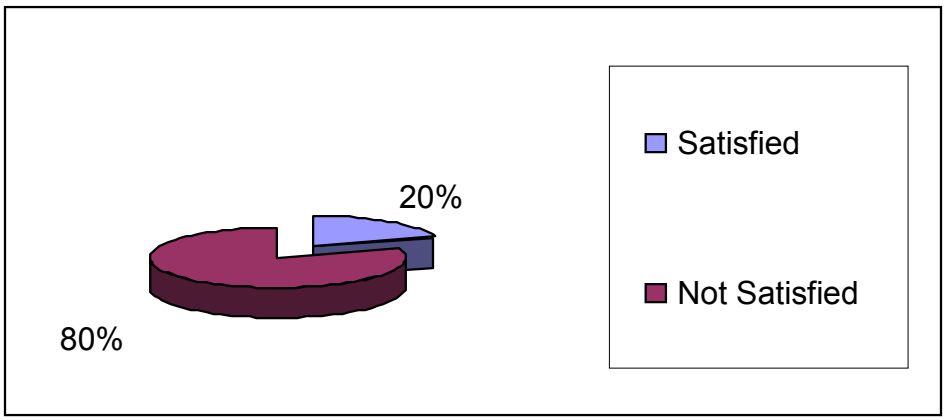

Figure 4.6: Trout Farmer Satisfaction with Number of INCOPESCA Visits

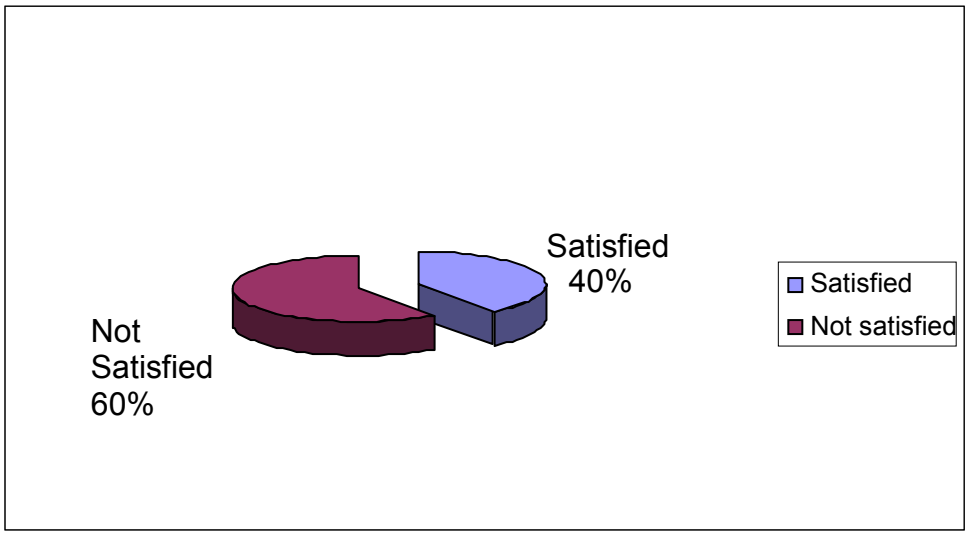

Figure 4.7: Tilapia Farmer Satisfaction with INCOPESCA Visits

Responses to Question 18 provide more proof that the farmers are not getting satisfactory visits and also not enough visits. Question 18 asked farmers how often the extension agents visited their farms in the last year, and whether they felt that this was sufficient. It can be seen in Figure 4.6 above that 12 of the 15 trout farmers who responded, or 80%, were unsatisfied, and only 20%, were satisfied with the number of visits they received. Figure 4.7 shows the same trend, 12 of the 20 tilapia farmers who responded, or 60%, were unsatisfied, and only 40%, were satisfied with the number of visits they received. This shows that there were an insufficient number of visits, it is also possible that the visits themselves were not providing all the information and training that the aquaculturists desired.

A major factor in the inadequate number of visits to the farms is the number of agents relative to the number farms. There are 719 Tilapia and Trout farms and only 10 extension agents to cover all of them. This means that one agent needs to cover about 80 farms! When we asked the extension agents how

many agents INCOPESCA needs to be effective, one responded that they need at least 10 more, and the other said at least 12 more agents were needed to be effective. However, it is unlikely that INCOPESCA will be able to hire more with their current budget, so their training methods used to teach aquaculturists need to be more effective.

When asked what the extension agents can provide to be more helpful (Question 14) (See Figures 4.8 and 4.9), 25 of the 39 trout and tilapia farmers responded with training as most important, visits, then equipment were also listed. Specifically, the aquaculturists desire: including training in the visits, offering training programs at home, giving more technical assistance in diseases and species, providing more assessments of all of the producers, providing more free journals, and bringing electronic water quality meters on all visits. While there was less variety in the types of responses, there were larger numbers for each of the three categories. Therefore, these three issues need to be focused on by the extension agents to help the aquaculturists.

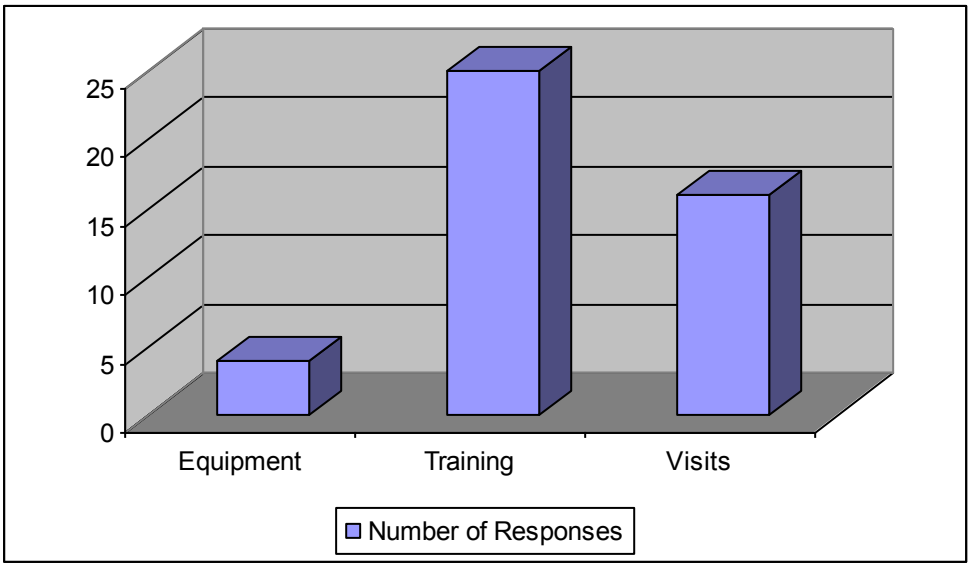

Figure 4.8: Areas in which Agents can be More Helpful

The fact that the aquaculturists felt that they were receiving insufficient training from the extension agents can also be seen from the responses to Question 14. The top response to requested areas of help was training from the agents. The answers indicate also that they are not receiving enough visits and that the visits are not considered as helpful as desired. One respondent had an excellent suggestion saying, "Include teaching in their visits." While bringing more equipment to farmers may be beyond the control of the extension agents, the amount and quality of training given to the farmers could be enhanced. Many farmers simply asked for more visits to their farms, but if more training and technical assistance could be incorporated in such visits, the quality of extension service would be greatly improved.

4.4 Market Assessment

Through our interviews of fish markets, supermarkets, and restaurants, as well as our survey of aquaculturists, we determined average market prices for tilapia and trout. The price that a farmer receives for his fish depends on to whom he is selling them, which depends in part on his capacity to produce. Larger farmers are able to raise fish year-round, and sell to supermarkets with a constant demand. Smaller farmers have to harvest all their fish at one time, and they do not receive great prices when they flood the market. For this reason, farmers who are part of a co-op generally receive higher prices for their fish because the co-op is able to systematically organize their members' production and harvesting to cater to larger markets. Figure 4.9 shows the percentage of trout farmers who are satisfied with the prices they receive for their product. Four out of the eight farmers who responded indicated they were dissatisfied with the prices they receive, and also mentioned that they would like INCOPESCA to assist them with expansion of markets. Interestingly, the satisfaction of farmers with market prices was neither related to the actual prices received nor the amount of experience that farmers had in aquaculture. This simply means that farmers need more help understanding marketing in order to raise their prices and their price satisfaction.

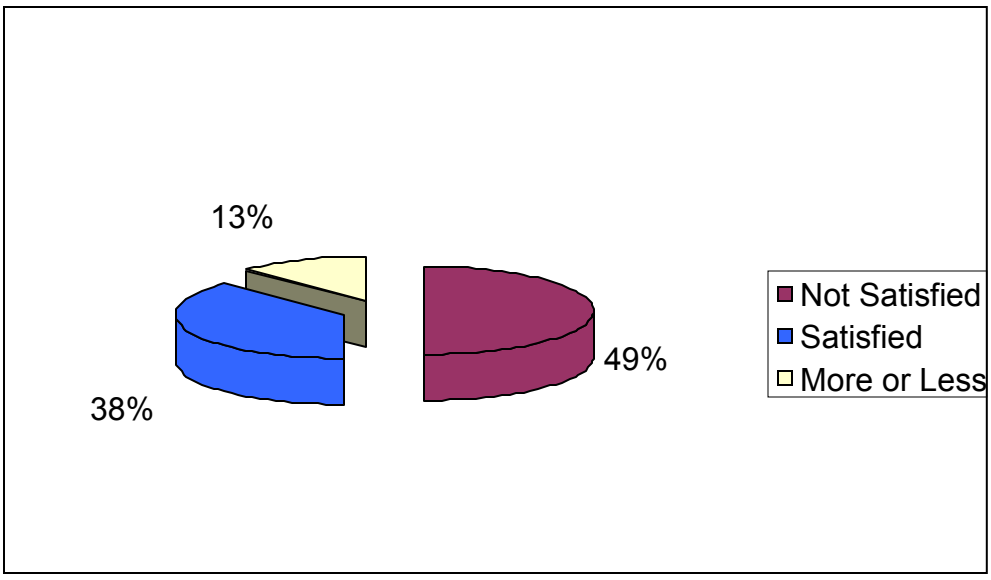

Figure 4.9: Trout Farmer Price Satisfaction

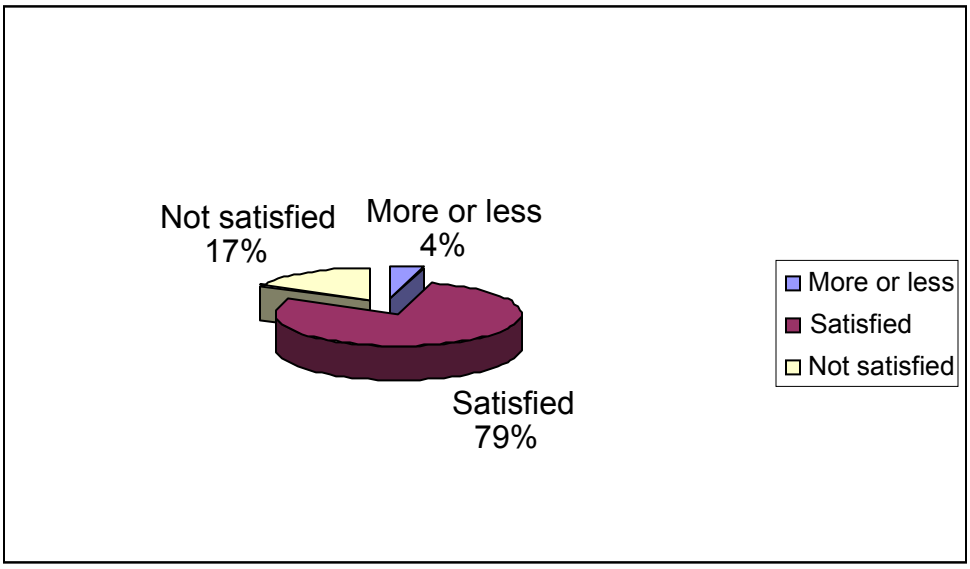

Figure 4.10: Tilapia Farmer Price Satisfaction

Among tilapia farmers, 79% are satisfied with the prices they receive for their fish, while only 17% are not satisfied and 4% percent are more or less satisfied (Figure 4.10). This may be due to the fact that tilapia farmers have a

marketing co-op, which enables them to bring their fish to larger and more distant markets, as well as negotiate better prices. The trout farmers have no marketing organization and are typically only able to sell their fish on their own farms or to the local markets.

Sixty-eight percent of the trout farmers sold their fish on their own farms, and fifty percent sold their fish off their farms, meaning that some farmers reached both markets.

In contrast to trout farmers, only twenty percent of the tilapia farmers sold their fish on the farm; the other eighty percent marketed in a wide variety of ways such as directly to consumers, to intermediaries, to restaurants, to fish markets, to supermarkets, and to local markets. As with trout, some farmers did sell to more than one market.

Supermarkets typically sell trout fillets for around €3,500 per kilogram (€3,564 at the AutoMercado in Barrio Dent). On average a trout farmer receives about €1,275 per kilogram of fish. However, the price varies from €600 to €2,000, and depends greatly in what form the fish are sold, (filleted, whole, fresh, frozen) whether it is sold in a restaurant on the farm, to sportsfisherman, or to stores as fillets.

Tilapia farmers, on average receive €900 per kilogram of fish, depending on how they are sold. Mas X Menos, a large Costa Rican supermarket chain, sells the tilapia they receive from Aquacorporación International for €1,314 per kilo for whole tilapia, €3,514 per kilo of fillet. AutoMercado, another supermarket chain sells tilapia at comparable prices (€3,545 per kilo of fillet, also from

Aquacorporación). One restaurant that we interviewed, Il Ponte Vecchio in San José, pays €3,500 per kilo of tilapia, an amount that normally provides five servings. Il Ponte Vecchio's customers requested about 80 kilos of tilapia dishes per year. While this restaurant purchased its tilapia from the AutoMercado supermarket, many restaurants purchase directly from farmers. The fish market Pescadería Elias in San José, sells tilapia that they receive from Aquacorporación for €1,400 per kilo of whole fish, and €2,000 per kilo of fillets.

The difference between what trout farmers receive for their fish and what they are sold for in the supermarket is €2,289 (€3,564 - €1,275), while the difference for tilapia farmers is €414 (€1,314 – €900). However, the supermarket price for trout is in fillets whereas the tilapia price is for whole fish, the most likely way that the farmers sell them. The difference between what trout farmers are paid and what the final consumers pay is much larger than that of tilapia. It is possible that this is due, in part, to the fact that the trout farmers do not have any marketing co-op, and are therefore unable to obtain prices as high as might otherwise be possible.

Chapter 5: Conclusion

From the analysis of our results, we have identified a number of problems that exist in small scale Costa Rican aquaculture. It is unrealistic to think that the aquaculturists will receive more formal aquaculture education, or that INCOPESCA will be able to hire more agents or buy more equipment at least in the short term. Neither group has the resources to accomplish these objectives. Therefore, the resources and knowledge of INCOPESCA agents need to be distributed more effectively to the aquaculturists. The best way to distribute information to the farmers is through the extension agents currently available to INCOPESCA. The best way for the farmers to learn is through informal or non-formal instruction from the extension agents. The extension agents have the required technical knowledge but are not trained in methods of informal and non-formal education. Therefore, a program needs to be developed to provide a training-of-trainers course to the extension agents about the best ways to educate the aquaculturists, which will ultimately improve aquaculture in Costa Rica. The first section of our recommendations will provide suggestions of methods for INCOPESCA to improve their extension services. The second section discusses some of the items that are of concern to the aquaculturists and that need to be included in the training programs.

In our analysis of INCOPESCA, there are three areas which stand out as areas that can be improved. These topics are in order of importance: equipment, marketing, and visits by extension agents. INCOPESCA specifically needs: more four-wheel drive vehicles with sufficient fuel, more equipment to provide farmers greater access to the instruments needed to test the pH, O_2, and temperature of water, more fish and egg size selectors for agents to use, and more nets. In addition INCOPESCA needs to open more markets for farmers (possibly by exportation of trout) and to analyze the market for fish more systematically and provide this information to the farmers. Finally, the agents need to reach the farmers more effectively.

If possible, INCOPESCA should purchase another four-wheel drive vehicle and increase the budget for fuel to allow for more visits to remote sites. However, budgeting restrictions may make this impossible unless more funding can be attained from the government. The most efficient way to distribute the vehicles is to pool the cars, so that when one is needed, it can be used by any employee. However, this might not be possible because INCOPESCA stations are distributed throughout the country, and a central vehicle pool may not be practical. However, the vehicles should be allocated in the areas where they are needed most. Some areas have better communication and will require fewer physical visits by agents, whereas other areas cannot be reached by telephone and require more frequent visits using vehicles. To increase efficiency, INCOPESCA agents should communicate via phone or publications and should be available whenever possible in case they are needed by an aquaculturist.

INCOPESCA needs more devices to test the quality of the water during visits. If they were able to purchase a device for each of the ten agents, the agents would be able to bring them to the farms when requested, or the farmers might even be able to pick them up from an office and use the device themselves for a day. This would decrease the time and resources used by the agents and would allow farmers to access the instruments at their convenience. If there are not enough devices for each agent, they should arrange a method of sharing them among people working in nearby locations. Another option recommended by one of the farmers was that the devices be sold to the aquaculturists without tax. Although INCOPESCA probably has no control over taxing, it may be possible for them to convince the Ministry of Agriculture and Livestock (MAG) or the central government to provide subsidies for the aquaculturists purchasing farm equipment. It could also be possible to receive a discount from instrument distributors, if INCOPESCA arranged a bulk purchase with farmers preordering. The size selectors for fish and eggs are probably too expensive for extension agents to each have one. However, it may be possible to purchase a few more and distribute them to each of INCOPESCA's aquaculture stations. They could be used by aquaculturists in the area when they are required. Nets are cheap, and more should be budgeted for and purchased by INCOPESCA, so the extension agents can make use of them when visiting farms.

Marketing is a major issue for many aquaculturists, and although it is not something that INCOPESCA can do for the farmers, they do have the ability to help organize farmers, conduct studies, and to help advertise the products. For

trout, an organization of farmers is a necessary step in improving aquaculture. Trout farmers need some form of association, or co-op, through which they can transport and sell their fish. The control of such an organization needs to be in the hands of the farmers themselves, however, if INCOPESCA contacted the farmers, arranged a meeting, and instructed them in the procedures necessary to create such an organization, it could set the wheels in motion to form a co-op. If this were to happen, it would greatly help current trout farmers by providing help with marketing, simplifying coordination and communication among farmers, as well as promoting a market for trout. A co-op could also be very helpful for novice trout farmers who, with INCOPESCA's help, would be able to start small trout ponds and instantly have market access, no matter how large the farm.

The farmers also desire more markets to be opened up for them. A co-op could help accomplish this, but INCOPESCA could also conduct surveys and studies on the possibility of opening new markets for trout and tilapia within the country and also for export. Small, individual farmers would not have the ability to produce enough for export, but a co-op would have less trouble doing so if the production levels of all members combined were high enough and steady enough. There are plenty of markets for fish worldwide. In 2001 the United States imported 6,853,929 pounds of tilapia from Costa Rica alone (Harvey, 2002). If INCOPESCA could demonstrate that there are available markets within Costa Rica or internationally, farmers could arrange for transportation and distribute their goods to these markets and more farmers might take up fish farming as well.

Finally, the farmers wanted extension agents to increase the number of visits to their farms. Since there are only ten agents, and nearly 800 aquaculturists, seeing all the farmers on a frequent basis would be difficult. If possible, INCOPESCA needs to hire more agents, but this is unlikely. However, it is possible to increase the efficiency of the agents and to provide the aquaculturists with more training and assistance without hiring more employees. If more agents were to be hired, it would be more useful to hire people not only with experience in aquaculture, but also with experience in marketing, education, and business. Agents do not lack technical knowledge -- they are well trained in those areas. However, they need to distribute their information and skills to the aquaculturists more efficiently. Thus, we have developed a program and process by which the extension agents can show, teach, and share more of their knowledge and equipment with the farmers. This plan utilizes informal education in the form of conferences, meetings, workshops, mentorships, newsletters, and possibly other means to provide farmers with the latest technical and financial information they need to conduct their businesses. To solve the various problems the aquaculturists have, the extension agents need to utilize different forms and methods of education.

Chapter 6: Recommendations

The previous chapter discussed some of the obstacles to improving aquaculture in Costa Rica and discovered how INCOPESCA can address some of these issues. The majority of our recommendations are embodied in the non-formal educational methods that should be used by the extension agents to train aquaculturists. We have also provided an overview of some of the important subjects about which farmers need instruction in, by the agents. The best method for INCOPESCA to disseminate their knowledge about aquaculture, equipment, and techniques to the rural farmers is through a *leader farmer program* based on informal training methods. These methods do not restrict the farmers to classrooms, and allow the agents to make the most efficient use of their time. A lengthy discussion of informal education methods can be found in the literature review. The second area in which aquaculturists seek training is marketing: for this we suggest a co-op be formed. Finally, the second goal of our project is to provide extension agents with the newest sources of information about aquaculture and education. In the following section will explain the program we developed:

6.1 Leader Farmer Program

The most effective way for the limited number of INCOPESCA agents to reach the large number of aquaculturists is through an apprenticeship program

based on “leader farmers” in each area (as seen in Figure 6.1). In this project the INCOPESCA agents identify leader farmers in each area of the country where there is a large density of aquaculture projects. Leader farmers are farmers in the community who already have a good knowledge of aquaculture or who aquaculturists already go to for advice. In each area there are farmers who have been practicing aquaculture for over 10 years and some have been doing it successfully for over 25; years, these are the farmers who should become leader farmers. After the farmers have been chosen, extension agents set up training programs where they meet with the farmers and teach them methods of presenting information and also teach them actual aquaculture techniques. For example, if one extension agent teaches three leader farmers, then each leader farmer teaches three more farmers, one extension agent has effectively reached nine people with only one trip or lesson. If the agent teaches nine leader farmers, and they teach nine or more aquaculturists, then over 80 people have been reached by only one extension agent. After learning some of the basic techniques of education and aquaculture, the leader farmers go back to their local communities and present the information they have learned to neighboring farmers. As the extension agents find new information to present to aquaculturists, they use the same system to continue the training process. This system can also be applied to MAG extension agents, who often provide assistance to rural farmers as well as aquaculturists.

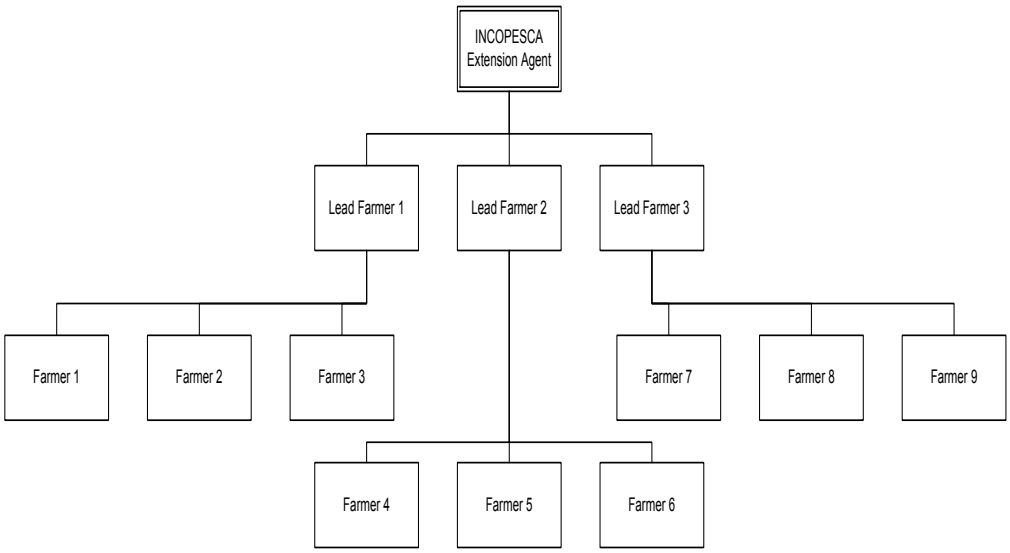

Figure 6.1: Reach of Leader Farmer Program

The first part of this program is choosing the leader farmers. Leader farmers don't necessarily need to be formally educated, but it is important that they are experienced in aquaculture and its techniques. The leader farmers should be farmers who have been successful in their own aquacultural business, and have been practicing aquaculture for a long period of time. It is also helpful if these farmers are respected members of their communities, and they may already be the first people that other aquaculturists come to for advice. After the leader farmers have been located, it is important to inform them that their job is important to INCOPESCA, and if there is no way to compensate the leader farmers with money, there should be a discount on purchasing their fry, a discounted price on feed, or some other appropriate compensation.

The next step is to find out when the leader farmers have free time to participate in the training program. For example, the farmers will not have time to participate while they are harvesting their fish. Each of them may have a different harvest schedule, and it is important to be able to work around these. If leader farmers with different work schedules can be found, so that one is busy while another isn't, this can keep the education efforts going continuously, instead of having to stop while the leader farmer is busy.

6.2 Training the Leader Farmers

After the leader farmers have been chosen and a schedule has been made for their own non formal education from INCOPESCA agents, then a schedule can be established for them to train local aquaculturists. The best way to educate the leader farmers is through workshops. Workshops can be held either on an aquaculturist's farm, at a hatchery, or at one of the INCOPESCA centers. The training site should be chosen according to the best location for the lesson to be delivered, or based on where it is most convenient for everyone to attend. In a workshop the material is presented using a variety of training methods, but it should include a lot of charts, graphs, examples, and as much hands on training as possible. The trainers are integrated into the process so that they learn and absorb as much information as possible.

INCOPESCA agents should hold different sessions about once a month. The first lesson needs to be on informal education and the different ways the leader farmers should present material to the farmers. The following sessions

should cover all aspects of aquaculture. After the basics of aquaculture have been taught follow-up workshops should cover the newest methods and technologies in aquaculture that are applicable to Costa Rica.

6.3 Training the Aquaculturists

After the leader farmers have attended the INCOPESCA workshops, they need to teach neighboring farmers what they have learned. This should be done through a mixture of workshops and mentoring/apprenticeship programs. The leader farmers can make a schedule for their own workshops, about once a week, or whatever is necessary to present the material to all aquaculturists in the area who are interested in learning it. If individual farmers have simple questions on aquaculture methods, they will no longer need to call INCOPESCA agents; they simply need to contact the leader farmers and have the material explained to them. Thus INCOPESCA agent visits can be reserved of absolute necessity.

If a farmer is having particularly difficult problems or if someone is new to aquaculture, a mentoring or apprenticeship program with leader farmers can be efficient. In this program the aquaculturists work closely with the leader farmers at the leader's farm to learn about all aspects of aquaculture: What type of system is preferable, what equipment is necessary, how to acquire fry and feed the fish, how to market the fish and how to handle the financial aspect of aquaculture.

Since the information taught by the leader farmers may not cover all of the most recent techniques and newest information, an INCOPESCA newsletter will have information and resources. The newsletter can include a schedule of all

INCOPESCA events, such as workshops, information about the newest methods and technology being used in aquaculture, advertisements for aquaculture supplies and equipment, articles analyzing fish food, aquaculture news, help wanted sections, marketing information and statistics, and any other information the aquaculturists may find interesting. Advertisements for equipment and help wanted ads can help pay for the cost of publishing and distributing the newsletter. The newsletter can either be distributed by INCOPESCA to leader farmers to be passed out to other aquaculturists, or it can be mailed out to those that subscribe to it.

Finally, since some of the aquaculturists do not have time or a way to get to workshops, INCOPESCA should have a library of prepackaged learning material for aquaculturists to borrow. The same workshops that are given to leader farmers can be recorded on tape or videotape and combined with printed material so that the farmers can access them. For example, if a farmer wants more information on food and nutrition of fish, he can get a package of information on the subject from INCOPESCA.

6.4 Marketing Assistance

Through these various methods listed above the aquaculturists will recieve a large amount of information on how to grow and produce fish. The last method for educating the aquaculturists deals with marketing aspect of the business. For effective marketing information the trout aquaculturists need to form a co-op. In a co-op all farmers produce their own fish. However, they can organize the sale of

the fish in the way that gets them the best prices. Co-ops have already been formed by some tilapia farmers, and most of the farmers that participate in the co-op are much more satisfied with the prices that they receive for their fish than those farmers who are not co-op members. One problem that the farmers face is that the prices fluctuate from one market to another. This fluctuation is because there is no constant supply of fish. Several farmers may harvest all of their fish at the same time creating a glut in the market and causing the price to drop. By contrast if no farmers are harvesting fish, the demand for them rises and prices go up accordingly. With a co-op the farmers can set a schedule for harvesting their fish so that there is a constant supply to the market. Also, when there is a constant supply of a product, the prices are less likely to fluctuate. With a co-op farmers can also pool their harvest so that they can produce a larger shipment to sell to a foreign market. The co-op can also work together on other subjects besides just marketing. They can help with distribution, have scheduled meetings to discuss aquaculture in general or to work out any problems that they are having, and share equipment among farmers. The farmers can pool their resources to buy their own tools and equipment, such as water meters, size selectors, and nets to be shared by all co-op members. This puts less pressure on INCOPESCA to provide farmers with this equipment, and allows the farmers to save money.

An important part of the training program and education is assessment of the teacher's teaching methods and also an assessment of what has been learned. It is important to be sure that the leader farmers are meeting the needs of the aquaculturists. It is also important to ensure that INCOPESCA agents are

meeting the needs of the farmers. The way the information is being presented to the farmers also needs to be evaluated periodically, to share ideas and find ways to improve.

6.5 Topics for Training

The following outline contains some of the topics that need to be taught to the aquaculturists. These suggestions will not be in nearly as much detail as the aquaculturists may need, but they will provide an overview of the general topics that need to be covered.

I. What aquaculturists want to know about

1. Feeding
    a. How much per fish
    b. How often
    c. When
    d. What stage of development is the fish in
2. Food
    a. Best kind
    b. What is optimal food (percentages of protein etc.)
    c. What stage of development is the fish in
    d. Supplemental food
        i. Trout outdoors with insects
        ii. Tilapia with duckweed
        iii. Tilapia with other animals

e. Price of food

3. Communication

a. Among aquaculturists

b. Between aquaculturists and agents

4. Marketing

a. Prices per fish

b. Co-op program

i. Export

ii. Schedule for sale

c. Demand for fish

d. Staggered harvest times

e. Transporting fish to market

f. New markets

II. Expanding Aquaculture

1. Co-ops
2. Discounted equipment
3. Financing

III. New Species

1. Dangers

a. Damage to local populations of fish

b. Damage to native habitat

c. Difficult to begin to grow and market, and bring into the country

d. Foods for different species are different

e. There is not enough knowledge about farming current species, why introduce new ones

2. Benefits

a. Might be easier to grow

b. Might make more money

c. More markets (diversity)

d. Might be easier to market

e. Could increase the market

IV. Suggestions for Further Research

1. Introduction of Species (catfish, salmon, etc)
2. Marketing of Aquaculture Products (co-op)

6.6 Educating the Agents

INCOPESCA extension agents already have a fairly good knowledge of aquaculture; however methods and technology are constantly changing. Because of this the agents need to be continually updated on new information, throughout their careers. The agents may also need access to established information such as tables showing proper feeding of fish, proper water temperatures, and water quality, along with other subjects. In order to learn or have access to this information, the agents need to follow a program of self-directed learning. Self-directed learning needs to be carried out whenever the extension agents have time to study. It includes looking up and researching any topics about aquaculture that

interest them or about which they need to know more. The primary tools for this type of learning are the internet, journals, and newsletters. The agents with access to a computer can easily find aquaculture information on the internet. A list of sites can be found in Appendix H. For those who do not have access to computers, INCOPESCA can distribute important articles obtained from the various sources. With new information, agents will be able to present the most up-to-date information to aquaculturists to help them become better farmers.

In the following pages are some of the websites, and other sources of information about aquaculture that we feel are best to use. There is a much more expanded version of this list in Appendix H with a brief description of each site.

6.6.1 Associations

http://ag.arizona.edu/azaqua/ata.html - American Tilapia Association - Provides information to those involved in tilapia production, to those interested in joining the industry, customers and consumers of farm-raised tilapia. This site is maintained at the University of Arizona. The site offers membership, information on farms and hatcheries, photos, links, tilapia prices, imports, markets, finance, bibliography, free farming software, ponds software, how to sex tilapia, information on aquaculture drugs and the FDA, and frequently asked questions.

http://www.cgiar.org/iclarm/ - International Center for Living Aquatic Resources Management - International research organization devoted to improving the productivity and management of aquatic resources for the benefit

of users and consumers in developing countries. ICLARM is located in the Philippines (with a sub-center in the Virgin Islands).

6.6.2 Societies

http://www.was.org/ - World Aquaculture Society (WAS) - Through its commitment to excellence in science, technology, education, and information exchange will contribute to the progressive development of aquaculture throughout the world. This site offers membership, an online store, informatuion for students, publications, training, links, etc.

http://www.fisheries.org/ - American Fisheries Society – The oldest and largest professional society representing fisheries scientists. The headquarters is located in Bethesda, Maryland. Web site offers membership, education, information on marketplaces, publications, information for students, links, etc.

6.6.3 Equipment

http://www.aquasales.com/ - Aquaculture Supply – Sells a wide variety of aquaculture supplies including: aeration and oxygenation, chemicals and therapeutants, disinfectants, electrical, feeding, filtration, fish handling, hatchery, heating and cooling, monitoring and control, netting, pumps, water quality, etc.

http://members.magnet.at/aquaculture/ - Aquaculture Technology – Sells aquaculture equipment including: net cage systems (cages, nets, boats), re-

circulation systems (systems, filters, tanks), water analyzers (meters, sensors, tests), and other equipment (graders, pumps, scales, etc); also offers consulting.

6.6.4 Feed

http://www.aquafeed.com/ - Aquafeed.com - Web-based resources for the aquafeed industry. Features include a monthly newsletter. Offers links, nutrition section – offering papers, ingredient profiles, species profiles, and information on hatcheries. Also has a tech center which features processing technologies storage and handling distributions, info on feeding systems, new products, and quality control.

http://www.rangen.com/rangen006.htm - Rangen, Inc. - Aquaculture Division is recognized as an international leader in the production of feeds and feed additives for aquaculture. Offers a variety of feeds for tilapia and trout.

6.6.5 Government

http://www.aquanic.org/ - USDA Aquaculture Site - is a gateway to the world's electronic aquaculture resources. Resources include info on systems and species, publications, newsletters, sites, contacts, news, online courses, and educators.

http://www.ustfa.org/ - U.S. Trout Farmers Association - Oldest commercial aquaculture trade organization in the United States and is devoted to trout and salmon farming. Features include membership, lots of info on trout and

salmon, a product and services directory, industry information and newletters.

6.6.6 Journals

http://www.sciencekomm.at/journals/hydro.html - Aquaculture Journals on the WWW - Directory of links to aquaculture, hydrology, marine and freshwater science journals.

6.6.7 Other Useful Web Sites

http://www.theaquaculturenews.com/ - Aquaculture News - Newspaper of the aquaculture industry. News items, editorials, columns, feature articles, and classifieds are included.

http://www.aquafind.com/ - Aquafind - Searchable database of producers of fish species, suppliers to the aquaculture industry, trading boards, articles, aquaculture links, market prices and more.

6.7 Final Thoughts

The goal of this project was to develop a training program for INCOPESCA extension agents so that they can educate the aquaculturists better. We have also provided the extension agents with sources of information about the newest aquaculture techniques, methods, and technologies. Based on our research, a program like this is necessary for the development of aquaculture in Costa Rica. If the small aquaculturists are provided with an effective marketing organization and training in the new aquaculture methods, they will be able to expand their

operations. New aquaculturists will be able to establish themselves easily, getting the necessary information quickly, and immediately having markets available. This will not only benefit individual aquaculturists, but the local communities, and the economy of Costa Rica as well. Hopefully when this happens, INCOPESCA will obtain the recognition and support from the government that it needs to increase funding, hire more extension agents, and purchase the necessary equipment. With this support, the aquaculture industry and Costa Rican society will be greatly enhanced.

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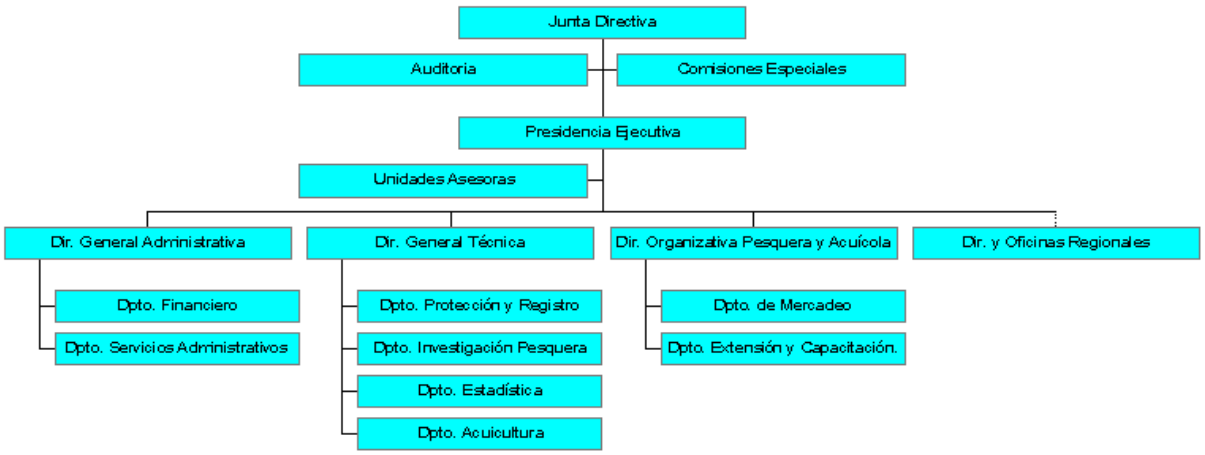
Appendix A: Description of INCOPESCA

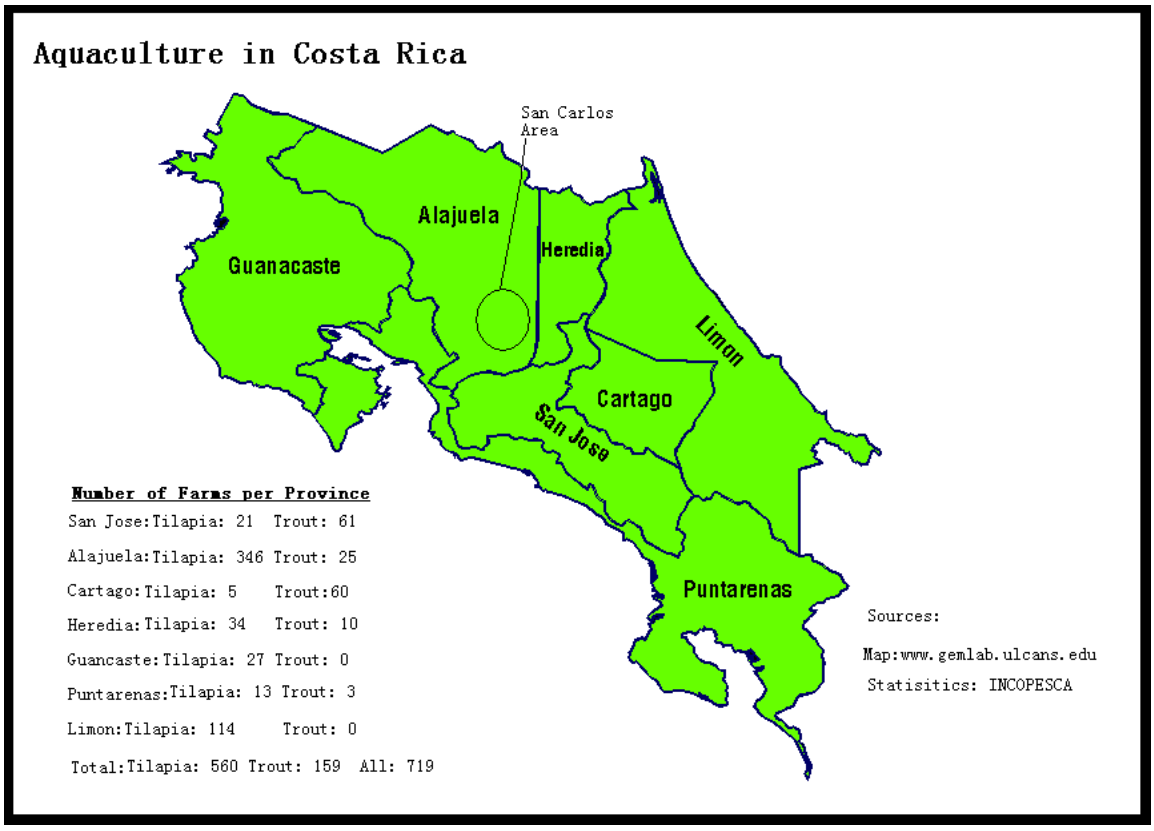
The mission statement of INCOPESCA is as follows: INCOPESCA promotes fishing and aquiculture development. The organization regulates, protects and administrates marine and aquaculture resources, providing a sustainable contribution to the economic development of the country. It is a government-funded organization with 12 offices throughout Costa Rica, and 17 positions to regulate the fishing and aquaculture industry. The main purpose is to promote aquaculture and the fishing industry in Costa Rica, they also promote eating fish for a healthy diet, with their slogan "for your health…. consume fish products." Since it is a government agency it serves the people of Costa Rica.

Figure A.1: Organizational Chart of INCOPESCA (INCOPESCA, 2002)



INCOPESCA employees are both hired and appointed by the government. The Head of INCOPESCA the Junta Directiva is appointed politically and changes with each presidential election. They usually have no experience in the field of fishing or aquaculture, because of this INCOPESCA's is not represented as well as it could be, also the head of INCOPESCA is constantly changing making it less efficient than it could be.(INCOPESCA, 2002

APPENDIX B: Map of the Locations of Aquaculture Farms in Costa Rica



Appendix C: Aquaculturist Survey Questionnaire

English Version:

We are 3 students from WPI, a university in the United States, we are in Costa Rica to do a project with INCOPESCA. We are trying to determine the state of aquaculture in Costa Rica and develop a training program for INCOPESCA extension agents. You are one of about 50 aquaculturists that have been selected to participate in our survey. We hope that our research will further the development of aquaculture in Costa Rica. Please take the time to answer the following questions, we appreciate any help you can give us.

The answers that you provide us with on this Questionnaire will be kept confidential. When you have finished the questionnaire, please seal in the attached envelope. INCOPESCA will not see individual responses to this survey; we will present the results without any personal information. We ask that you please respond on the questionnaire as honestly and accurately as possible so that we can better help INCOPESCA and aquaculture in general in Costa Rica. The results of this survey will be available through INCOPESCA to anyone interested.

Thank you for your time.

David Graham
Walter Johnson
Adam Lee

If you need more space for your answers, please feel free to use the back of the paper for your answers.

1. How many people work with you?

2. What species of fish do you raise?

3. Approximately how many kilograms of fish do you produce annually?

4. Where and to whom do you sell your fish?

    How much do you receive per kilogram of fish?

    Are you satisfied with the prices you receive?

5. Do you export your fish? (yes or no) If so, to which countries?

6. How extensive is your experience in aquaculture?

7. What level of education do most aquaculturists in Costa Rica have?

8. Are there Universities in this area that offer degree programs specializing in aquaculture?
-If so, do you know whom we would want to contact at these schools?

9. What is required to conduct aquaculture in Costa Rica?

10. What technologies are typically available and unavailable in Costa Rica for aquaculture?

11. How do you feel about the introduction of species of fish into Costa Rica for aquaculture?

12. What specific biological pathogens for tilapia or trout are of issue in Costa Rica, and what measures need to be taken to keep the fish and their environment healthy?

13. Do you think that the INCOPESCA agents have the knowledge that you need to carry out your aquaculture business?

14. How could the INCOPESCA extension agents be more helpful?

15. What do you suggest that the organization INCOPESCA do to better help aquaculturists?

16. Do you feel that the INCOPESCA extension agents are helpful, and reasonable in their methods of assisting aquaculturists?

17. Do you have any problems communicating with INCOPESCA, either the extension agents or with the agency directly?

If so, what are they?

18. How often did the field agents visit your farm, last year?

Do you feel that this was sufficient?

19. Do you know any other people we could talk to about aquaculture?

20. Do you have any other recommendations that will help further our research?

21. What is your name?
Please remember to seal in the attached envelope. Thank you again

Spanish Version:

Somos 3 estudiantes de WPI, una universidad en los Estados Unidos, nosotros estamos en Costa Rica para hacer un proyecto con INCOPESCA. Estamos intentando determinar el estado de la acuacultura en Costa Rica y desarrollar un programa de entrenamiento para los agentes de la extensión de INCOPESCA. Usted es uno de cerca de 50 acuacultures a los que hemos salacionado para si participa de nuestra encuesta. Esperamos que nuestra investigación fomente el desarrollo de la acuacultura en Costa Rica. Queramos por que de conteste a las preguntas siguientes, nosotros apreciamos cualquier ayuda que usted pueda darnos.

Las respuestas que usted nos brinde en este cuestionario serán confidenciales. Cuando termine el cuestionario, por favor sellelo en el sobre adjunto. INCOPESCA no vera respuestas individuales a este cuestionario; presentaremos los resultados sin ninguna información personal. Le pedimos que honestamente, y bien hecho como sea posible para que podamos ayudar a INCOPESCA y a la acuacultura en general en Costa Rica. Los resultados de esta encuesta estarán disponibles a través de INCOPESCA para cualquier interesado.

Gracias para su tiempo.

David Graham
Walter Johnson
Adam Lee

Si usted necesita más espacio para sus respuestas sientase en libertad de usar el dorso de la página para sus respuestad.

1. ¿Cuántas personas trabajan con usted?

2. ¿Qué especies de pescados cultiva usted?

3. ¿Cuántos kilogramos de pescados produce usted aproximadamente por ano?

4. ¿Dónde y a quien vende usted sus peces?
    ¿Cuanto recibe usted para un kilo de peces?
    ¿Tiene satisfecho con los precios que recibe?

5. ¿Exporta usted sus peces? (si o no) si es así a que países

6. ¿Cuan extensa es su experiencia en acuacultura?

7. ¿Qué nivel educativo la mayoría de los aquaculturists en Costa Rica tiene?

8. ¿Hay instituciones en esta área que ofrezcan los programas de grado que se especializan en acuacultura?

-Si es así ¿Sabe usted quién a podríamos contactar en estas instituciones?

9. ¿Qué se requiere para mejorar la acuacultura en Costa Rica?

10. ¿Qué tecnologías están típicamente disponibles e inasequibles en Costa Rica para la acuacultura?

11. ¿Qué piensa usted sobre la introducción especies en peces en Costa Rica para la acuacultura cultivo?

12. ¿Qué patógenos biológicos específicos para la tilapia o trucha son problemas en Costa Rica, y qué medidas necesitan ser tomadas para de la subsistencia los peces y su ambiente sano?

13. ¿Piense usted que los técnicos de INCOPESCA tienen el conocimiento que usted necesita llevar a cabo su negocio acuicultura?

14. ¿Cómo podían los técnicos de INCOPESCA ser más provechosos?

15. ¿Qué sugiere usted que la organización INCOPESCA haga para mejorar la ayuda a los acuaculturitas?

16. ¿Piense usted que los técnicos de INCOPESCA son provechosos, y razonables en sus métodos de asistir a acuaculturitas?

17. ¿Tiene usted problemas para comunicarse con INCOPESCA, los técnicos o con la agencia directamente?

Si es así, ¿Cuales son?

18. ¿Cuan a menudo visitaron los técnicos de campo a menudo su granja, en el año pasado?

-¿Usted piensa que esto fue suficiente?

19. ¿Conoce usted otra gente que podríamos hablar sobre la acuacultura?

20. ¿Tiene usted otras recomendaciones que ayuden más nuestra investigación?

21. ¿Cuál es su nombre?

Por favor recuerde sellar en el sobre adjunto.
Gracias otra vez.

Appendix D:

INCOPESCA Extension Agent Survey Questionnaire:

English Version:

We are 3 students from WPI, a university in the United States, we are in Costa Rica to do a project with INCOPESCA. We are trying to determine the state of aquaculture in Costa Rica and develop a training program for INCOPESCA extension agents. We hope that our research will further the development of aquaculture in Costa Rica. Please take the time to answer the following questions, we appreciate any help you can give us.

The answers that you provide us with on this Questionnaire will be kept confidential .When you have finished the questionnaire, please seal in the attached envelope. INCOPESCA will not see individual responses to this survey; we will present the results without any personal information. We ask that you please respond on the questionnaire as honestly and accurately as possible so that we can better help INCOPESCA and aquaculture in general in Costa Rica. The results of this survey will be available through INCOPESCA to anyone interested.

Thank you for your time.

David Graham
Walter Johnson
Adam Lee

If you need more space for your answers, please feel free to use the back of the paper for your answers.

1. What is your position in INCOPESCA?

2. How many years have you worked as an INCOPESCA agent?

3. How extensive is your experience in aquaculture?

4. What level of education do you, and most other INCOPESCA extension agents have?

5. Are there any distance education programs for aquaculture in Costa Rica?

Do you believe that such a program is/would be beneficial?

6. How do you feel about the current training program for extension agents?

7. How do you feel that it could be improved?

8. In which area would you like to receive training in?

Please rank in order of importance (1-5, 1 being the most important):

Aquaculture Systems	___
Nutrition/Feeding	___
Diseases	___
Businesses	___
Reproduction/Breeding	___

9. Would it be feasible to send agents to the U.S. for training?

10. What innovative aquaculture technologies do you think could and should be introduced to Costa Rica?

11. How do you feel about introducing species of fish into Costa Rica and the possible ecological impacts for aquaculture?

12. What is your opinion about the introduction of genetically altered fish into the country to improve the aquaculture business?

13. Do you take into account environmental aspects in your aquaculture projects?

14. In what ways do you typically assist aquaculturists?

15. What is the principal problem with the development of aquaculture in Costa Rica?

16. Do you feel there are any other obstacles that slowed the development of aquaculture in Costa Rica?

17. Do you think there are problems with the technical part of aquaculture in Costa Rica?

If so, what are they?

18. Does INCOPESCA have enough technicians to help develop aquaculture in Costa Rica?

If not, how many do you feel are needed?

19. Do you feel there are any problems with communication in INCOPESCA?

If so, what are they?

20. Do you feel that you are helping the Aquaculturists?

If not, why?

21. Do you know any other people we could talk to about aquaculture?

22. Do you have any other recommendations that will help further our research?

23. What is your name?

Please remember to seal in the attached envelope. Thank you again

Spanish Version:

Somos 3 estudiantes de WPI, una universidad en los Estados Unidos, nosotros estamos en Costa Rica para hacer un proyecto con INCOPESCA. Estamos intentando determinar el estado de la acuacultura en Costa Rica y desarrollar un programa de entrenamiento para los agentes de la extensión de INCOPESCA. Esperamos que nuestra investigación fomente el desarrollo de la acuacultura en Costa Rica. Queramos por que de conteste a las preguntas siguientes, nosotros apreciamos cualquier ayuda que usted pueda darnos.

Las respuestas que usted nos brinde en este cuestionario serán confidenciales. Cuando termine el cuestionario, por favor séllelo en el sobre adjunto. INCOPESCA no vera respuestas individuales a este cuestionario; presentaremos los resultados sin ninguna información personal. Le pedimos que honestamente, y bien hecho como sea posible para que podamos ayudar a INCOPESCA y a la acuacultura en general en Costa Rica. Los resultados de esta encuesta estarán disponibles a través de INCOPESCA para cualquier interesado.

Gracias para su tiempo.

David Graham
Walter Johnson
Adam Lee

Si usted necesita más espacio para sus respuestas sientase en libertad de usar el dorso de la página para sus respuestad.

1. ¿Cuál es su posición en INCOPESCA?

2. ¿Cuántos años ha trabajado usted como agente de INCOPESCA?

3. ¿Cuan extensa es su experiencia en acuacultura?

4. ¿Qué nivel educativo usted, y la mayoría de los otros agentes de la extensión de INCOPESCA tiene?

5. ¿Hay programas de educación a distancia para la acuacultura en Costa Rica?
   ¿Cree usted que tal programa sea beneficioso?

6. ¿Qué piensa usted sobre el programa de entrenamiento actual para los agentes de extensión?

7. ¿Cómo cree usted podría que ser mejorado?

8. ¿En que área quisiera usted se le de capacitación?
Por favor numera en orden de importancia (1-5, 1 es la más importante):

-Cultivos (sistemas) ___
-Alimentación ___
-Enfermedades ___
-Comercializaciones ___
-Reproducción ___

9. ¿Sería posible enviar técnicos a los Estados Unidos para el entrenamiento?

10. ¿Qué tecnologías innovadoras de la acuacultura piensa usted que podrían y deben ser introducidas en Costa Rica?

11. ¿Qué opina usted sobre la introducción de peces en Costa Rica mejorar y posibles impacto ecológico para la acuacultura?

12. ¿Cual es su opinión sobre la introducción al país de peces mejorados genéticamente para mejorar las líneas de trabajo en acuicultura?

13. ¿Se toma en cuenta la parte ambiental en los proyectos acuicolas?

14. ¿De qué maneras usted ayuda típicamente a aquaculturists?

15. ¿Cuál es el problema principal con el desarrollo de la acuacultura en Costa Rica?

16. ¿Cuáles son otros obstáculos que retardaran el desarrollo de la acuacultura en Costa Rica?

17. ¿Piensa usted que hay problemas con la parte técnica de acuacultura en Costa Rica?
Si es así, ¿Cuales son?

18. ¿Tiene INCOPESCA bastantes técnicos que ayudan a desarrollar la acuacultura en Costa Rica?
Si no, ¿Cuantos son suficientes?

19. ¿Siente usted que hay problemas con la comunicación en INCOPESCA?

Si así, ¿cuales son?

20. ¿Siente usted que usted está ayudando en la Acuacultura?
Si no, ¿por que?

21. ¿Conoce usted otra gente que podríamos hablar sobre la acuacultura?

22. ¿Tiene usted otras recomendaciones que ayuden más en a nuestra investigación?

23. ¿Cuál es su nombre?

Por favor recuerde sellar en el sobre adjunto.
Gracias otra vez.

Appendix E:

Market Survey Questionnaire:

English Version:

We are 3 students from WPI, a university in the United States, we are in Costa Rica to do a project about aquaculture, with INCOPESCA. We are trying to determine the state of aquaculture in Costa Rica and develop a training program for INCOPESCA extension agents. We hope that our research will further the development of aquaculture in Costa Rica. Please take the time to answer the following questions, we appreciate any help you can give us.

The answers that you provide us with on this Questionnaire will be kept confidential; we will present the results without any personal information. We ask that you please respond on the questionnaire as honestly and accurately as possible so that we can better help the aquaculturists in Costa Rica. The results of this survey will be available through INCOPESCA to anyone interested.

Thank you for your time.

David Graham
Walter Johnson
Adam Lee

1.) Do you sell tilapia?

2.) How much do you pay for a kilogram of tilapia?

    -What determines the price?

3.) How much do you sell a kilogram of tilapia for?

4.) Approximately how many kilograms do you sell in one year?

5.) Do you buy your tilapia directly from the farmers or from a middle man?

    -Who specifically do you get it from?

6.) How often do you get shipments of tilapia?

7.) Do you sell trout?

8.) How much do you pay for a kilogram of trout?

-What determines the price?

9.) How much do you sell a kilogram of trout for?

10.) Approximately how many kilograms of trout do you sell in one year?

11.) Do you buy your trout directly from the farmers or from a middle man?

-Who specifically do you get it from?

12.) How often do you get shipments of trout?

Thanks Again

Spanish Version:
Somos 3 estudiantes de WPI, una universidad en los Estados Unidos, nosotros estamos en Costa Rica para hacer un proyecto sobre acuicultura con INCOPESCA. Estamos intentando determinar el estado de la acuicultura en Costa Rica y desarrollar un programa de entrenamiento para los agentes de la extensión de INCOPESCA. Esperamos que nuestra investigación fomente el desarrollo de la acuacultura en Costa Rica. Queramos por que de conteste a las preguntas siguientes, nosotros apreciamos cualquier ayuda que usted pueda darnos.

Las respuestas que usted nos brinde en este cuestionario serán confidenciales; presentaremos los resultados sin ninguna información personal. Le pedimos que honestamente, y bien hecho como sea posible para que podamos ayudar los acuicultores en Costa Rica. Los resultados de esta encuesta estarán disponibles a través de INCOPESCA para cualquier interesado.

Gracias para su tiempo.

David Graham
Walter Johnson
Adam Lee

1.) Vende Ud. Tilapia?

2.) Cuanto paga para un kilo de Tilapia?

-como determine el precio?

3.) Cuanto recibe para un kilo de Tilapia?

4.) Cuantos kilos de Tilapia vende Ud. Aproximadamente por año?

5.) Compra los Tilapia directamente de las acuiculturas o de una otra persona?

-De quien en particular compra ud. Tilapia?

6.) Cuan a menudo recibe un cargamento de Tilapia?

7.) Vende Ud. Trucha?

8.) Cuanto paga para un kilo de Trucha?

-como determine el precio?

9.) Cuanto recibe para un kilo de Trucha?

10.) Cuantos Kilos de trucha vende ud. Aproximadamente por año?

11.) Compra las Truchas directamente de las acuiculturas o de una otra persona?
-De quien en particular compra ud. Trucha?

12.) Cuan a menudo recibe un cargamento de Trucha?

Gracias otra vez.

Appendix F:

Interview Protocols for Aquaculture Educators

1. What is your name?

2. What is your position at the University?

3. ¿How extensive is your experience with aquaculture?

4. What is the principle problem with the development of aquaculture in Costa Rica?
   -Are there technical problems?

5. What does your aquaculture program include?

6. Do you use hands-on teaching methods, and how do you feel about non-formal education?

7. Do you train extension agents?

    a. What do you think are the best methods to use?

8. What do you think would be the best methods for INCOPESCA's extension agents to use to educate the aquaculturists?

9. Do you know any other people we can talk to about aquaculture or aquaculture education?

10. What are the problems with INCOPESCA?

11. Are there any other Universities that have aquaculture programs?

12. Do you have any recommendations to help our study of aquaculture in Costa Rica?

Appendix G: Definition of an IQP

One of Worcester Polytechnic Institute's (WPI) graduation requirements is to complete an Interactive Qualifying Project (IQP). An IQP is a project in which students research and apply technology and humanistic knowledge to a problem in a society.

WPI had seven IQP projects this summer of 2002, in Costa Rica. They involved various corporations, and governmental organizations. The students each applied to the projects, listing them in order of preference. While technical aspects were involved in every project, none of the students were experts in these subjects. As the definition of an IQP involves a social aspect, the projects were not only technical. Each project involved social science, as well as a humanitarian aspect.

Our project, "Establishing a Training Program for Extension Agents in Costa Rica," embodies the definition of an IQP. The technical aspects involve utilizing non-formal education methods to distribute aquacultural techniques and technology to small aquaculturists in the country. The social aspects are how the development of aquaculture will impact the culture and rural societies of Costa Rica.

All three of us that worked on this project have developed our Spanish and communication skills in general, teamwork skills, our time management abilities, as well as expanding our general knowledge and worldviews. Working in, and attempting to improve, a developing country has broadened our horizons to the

social implications of the actions of our everyday lives. We consider ourselves lucky to have participated in such an insightful, educational project.

Appendix H: Comprehensive List of Web Sites

Associations, Societies, Institutions, and Organizations

http://ag.arizona.edu/azaqua/ata.html - American Tilapia Association - Provides information to those involved in tilapia production, to those interested in joining the industry, customers and consumers of farm-raised tilapia. This site is maintained at the University of Arizona.

http://asae.org/ - American Society of Agricultural Engineers - Not-for-profit professional and technical organization of members worldwide interested in engineering knowledge and technology for food and agriculture, associated industries, and related resources. ASAE is located in Michigan.

http://www.easonline.org/home/en/default.asp - European Aquaculture Society (EAS) - The European Aquaculture Society (EAS) was established on April 30, 1976 as an international, non-profit association, with the principal objective of being the European forum for contacts and information exchange between all actors within the aquaculture industry.

http://www.feap.org/ - Federation of European Aquaculture - Created in 1969 for salmoind producers and modified in 1994 to include all aspects of aquaculture.

http://www.aesweb.org/ - Aquacultural Engineering Society - The AES provides a focal point for the discussion of engineering related topics concerning the production, processing and distribution of aquatic organisms and products derived from these sources.

http://www.salmonchile.cl/ - Asociación de Productores de Salmón y Trucha de Chile - directorio de Compañías chilenas productoras, Productos, Noticias, Links, Estadísticas, Publicidad.

http://www.andah.org/ - Association National of Aquaculturists of Honduras

http://www.aquaculture.ca/ - Canadian Aquaculture Industry Alliance (CAIA) - National organization, a federation of regional and sectoral associations working with and for individuals, businesses and associations whose work is related to the aquaculture industry. This includes those farming finfish and shellfish. Suppliers and supporters of the industry are also an important part of our alliance.

http://www.colaqua.org/ - Colorado Aquaculture Association - Promotes and supports aquaculture development in Colorado and elsewhere. Membership in the Association is available.

http://waterland.net/ngva/ - Dutch Aquaculture Society (NGvA) - Association with the aim to raise awareness and disseminate knowledge on responsible aquaculture business in The Netherlands.

http://www.fb.com/ - American Farm Bureau - The nation's largest general farm organization.

http://www.fisheries.org/ - American Fisheries Society - Oldest and largest professional society representing fisheries scientists. The headquarters is located in Bethesda, Maryland.

http://www.ifmt.nf.ca/mi/aac/ - Aquaculture Association of Canada - Aims to foster an aquaculture industry in Canada and to promote the study of aquaculture and related science in Canada.

http://www.nal.usda.gov/afsic/afsaqua.htm - Alternative Aquaculture Association - Non-profit organization providing information on alternative and traditional methods of aquaculture, emphasizing , low-energy and practical applications, re-circulating technologies, and educational and backyard systems.

http://www.natlaquaculture.org/ - National Aquaculture Association - Provides a unified national voice for aquaculture that insures its sustainability, protects its profitability, and encourages its development in an environmentally responsible manner. NAA addresses regulatory and legislative issues confronting the US aquaculture industry.

http://www.marine-ed.org - National Marine Educators Association - Brings together those interested in the study and enjoyment of the world of water--both fresh and salt. Affiliated with the National Science Teachers Association and the American Association for the Advancement of Science, NMEA provides a valuable focus for marine and aquatic studies world-wide.

http://www.naia.nf.net/ - Newfoundland Aquaculture Industry Association - promotes the development of aquaculture and its industry in the province of Newfoundland.

http://www.aquaculture-online.org/ - ACTED Online - Service providing current information to the worldwide aquaculture community. This site is maintained by the Aquaculture Division of the Harbor Branch Oceanographic Institute Inc.

http://ag.ansc.purdue.edu/aquanic/iaa/index.htm - Indiana Aquaculture Association - Aims is to assist in promoting production and marketing of aquaculture products, to provide for the educational advancement of members, to encourage scientific research in Aquaculture, to promote exchange of information among members, to promote public interest in aquaculture.

http://www.cawthron.org.nz/ - Cawthron Institute - New Zealand's first private research institute, specializing in aquaculture, biosecurity, coastal & estuarine ecology, freshwater ecology and analytical laboratory services.

http://scilib.ucsd.edu/sio/index.html - Scripps Institution of Oceanography Library - Offers links, databases, electronic journals and archives.

http://www.texasaquaculture.org/ - Texas Aquaculture Association - The Texas Aquaculture Association maintains a web site for the non-profit organization's members and public to inform them about aquaculture in Texas.

http://www.msstate.edu/dept/tcnwac/ - Thad Cochran's National Warmwater Aquaculture Center - The NWAC provides a synergistic environment for scientists to work toward a common goal and provides a single point of coordination for all aquaculture research, extension, and diagnostic activities.

http://www.wisconsinaquaculture.com/ - Wisconsin Aquaculture Association - Private non-profit corporation, consists of growers of aquatic species and is 100% industry-led.

http://www.was.org/ - World Aquaculture Society (WAS) - Through its commitment to excellence in science, technology, education, and information exchange, will contribute to the progressive development of aquaculture throughout the world.

http://www.cherrysnapper.com/ - World Tilapia Association - Formed to encourage and provide web site for multilingual communication between people at all levels of tilapia use and production at minimal cost by providing Newsletters and bulletin boards on Web site.

http://agnic.org/ - AgNIC - Agriculture Network Information Center. A central repository for agricultural related information on the web. Focal point for quality Ag-related information and subject specialists. Created by the National Agricultural Library and land-grant universities.

http://nl.aquarius.euro.org/ - Aquarius - Pan-European network for the aquacultural community, e.g. farmers, the support industry, scientists and students. an integrated means of becoming informed and educated using state of the art information technology. a huge visual information database with a practical and a scientific approach. an initiative of a consortium of European universities and their business partners.

http://www.eiard-infosys.org/ - European Initiative for Agricultural Research for Development (EIARD) - European Information System on Agricultural Research for Development and Related Fields.

http://www.gaalliance.org/ - Global Aquaculture Alliance - The Global Aquaculture Alliance is an international, non-profit trade association dedicated to advancing environmentally responsible aquaculture. As its top goal, GAA is working to finalize the Responsible Aquaculture Program of certified aquaculture production standards. GAA also publishes the Global Aquaculture Advocate, a bimonthly magazine that presents practical articles on efficient and sustainable aquaculture technology, updates on GAA activities and other aquaculture information.

http://www.fisheries.org/fhs/ - Fish Health Section - American Fisheries Society includes qualification for certified pathologists and inspectors as well as the online edition of the Section newsletter.

http://www.akvaforsk.com/ - AKVAFORSK - Institute of Aquaculture Research - Institute of Aquaculture Research AS - AKVAFORSK is one of the world's leading research institutes specializing in selective breeding, nutrition and product quality in aquaculture. In addition, the research activity at AKVAFORSK includes questions related to fish health, environmental aspects and farm management. The goal of AKVAFORSK is to provide and publish knowledge about aquaculture, contributing to a strong, profitable industry, beneficial to world society.

http://www.hatcheryinternational.com/ - Hatchery International - A specialty publication for public and private finfish and shellfish hatchery facilities.

http://www.agedhq.org/council.html - National Council for Agricultural Education - Aquaculture Educational site on which the 1998 aquaculture inservice data and sites have been posted.

http://www.oceanicinstitute.org/ - Oceanic Institute - Center for Applied Aquaculture is a private nonprofit research organization dedicated to the development and transfer of practical oceanographic, marine environmental , and aquaculture technologies

http://www.aps.uoguelph.ca/~aquacentre/ - Ontario Aquaculture Centre - The Ontario Aquaculture Centre provides extension, education and research in the field of aquaculture, and is a joint venture between the University of Guelph and the Ontario Ministry of Agriculture, Food and Rural Affairs.

http://www.cgiar.org/iclarm/ - International Center for Living Aquatic Resources Management - - International research organization devoted to improving the productivity and management of aquatic resources for the benefit of users and consumers in developing countries. ICLARM is located in the Philippines.

http://www.wvaquaculture.com/ - West Virginia Aquaculture Association - resources and information to assist members and others in developing a successful and rewarding aquaculture venture. A collection of useful aquaculture tools, resources and organizations.

http://www.wisconsinaquaculture.com/ - Wisconsin Aquaculture Association - Private non-profit corporation, consists of growers of aquatic species and is 100% industry-led.

Universities

http://134.29.163.134/aqua/ - Alexandria Technical College Aquaculture - Two year AAS Degree Aquaculture Training Program.

http://www.morrisville.edu/academics/ag_natural resources/aquaculture/index.htm - Aquaculture and Aquatic Science - SUNY Morrisville. The Aquaculture and Aquatic Science major is designed to provide fundamental training in aquaculture, fisheries biology, limnology and aquatic biology. Students receive a broad based education by exploring a variety of subjects in fisheries and aquatics. Practical, hands-on experience is emphasized, using an operational aquacultural complex and a wide assortment of laboratory and field equipment.

http://www.scieng.utas.edu.au/aqua/ - Aquaculture - University of Tasmania - Established Australia's first and thus far only Department of Aquaculture.

http://www.uidaho.edu/aquaculture/ - Aquaculture Research Institute - University of Idaho. The Aquaculture Research Institute at the University of Idaho assists in the development and expansion of aquaculture statewide through research, education and outreach in the areas of both commercial and conservation aquaculture. Aquaculture has always been an important industry to Idaho's economy, and the programs and studies underway at the UI in behalf of this valuable industry are exciting and innovative.

http://db.lib.uidaho.edu/aquaculture/ - University of Idaho 's BRS Aquaculture Databases - Search the database for Aquaculture Related Materials, the database contains selected literature (journal articles, reports, proceedings) related to freshwater salmon. Some items date as far back as 1974.

http://www.auburn.edu/aunorth/ - Aquaculture Research Unit - University of the North South Africa. Postgraduate training in warm-water aquaculture in southern Africa.

http://ag.arizona.edu/azaqua/ - Arizona Aquaculture - University of Arizona aquaculture site.

http://www.ag.auburn.edu/dept/faa/index.htm - Auburn University - Department of Fisheries and Allied Aquaculture.

http://www.amc.edu.au/ - Australian Maritime College - The College Mission is 'the provision of the highest quality education, training and consulting, and the conduct of applied research of international distinction, to meet the needs of the maritime sector.'

http://www.liverpool.k12.ny.us/LHS/bero/LHSaquaculture.html - Liverpool High School Aquaculture Center - Three species of trout and two species of tilapia are reared in our center designed to provide students with a taste of aquaculture as a future career.

http://www.msstate.edu/dept/crec/caumain.html - Mississippi State University Coastal Aquaculture Unit - Conducts research on any species of fish or invertebrates of interest or importance to the state's aquaculture industry. Primary emphasis is on marine and brackish water species. Additionally, CAU also conducts research regarding microbiology, coastal wetlands, estuarine ecology, coastal water quality, and aquaculture economics.

http://aqua.ucdavis.edu/ - California Aquaculture - An aquaculture site hosted by the University of California Davis with emphasis on aquaculture in California and the Western United States. This site is maintained by the University of California, Davis.

http://www.upei.ca/~cai/ - Canadian Aquaculture Institute - Joint initiative of the University of Prince Edward Island and Holland College Community College of Prince Edward Island. The Institute provides international continuing education in aquaculture medicine, fish health, and management.

http://www.nsac.ns.ca/pas/Aqua/aquaculture.htm - NSAC Aquaculture web site - Nova Scotia Agricultural College Aquaculture web site, describes the aquaculture courses, research and facilities at the college.

http://www.ag.ohio-state.edu/~prec/aqua/ - Ohio State University Centers at Piketon - Aquaculture Program with information on the page for various cultures. The Centers have also other program areas that could help with getting business of Aquaculture started.

http://www.iitkgp.ernet.in/acads/dept/AG/index.php - Indian Institute of Technology - Kharagpur - offers a two years master degree in aqua engineering and a number of industry and sponser research activities are going on.

http://aquafishprog.ucdavis.edu/ - Center for Aquatic Biology and Aquaculture - Gateway to information on aquaculture research and activities on the UC Davis campus. Formerly Aquaculture & Fisheries Program, UC Davis.

http://www.uaex.edu/aqfi/default.htm - University of Arkansas at Pine Bluff - Department of Aquaculture and Fisheries with information on careers, facilities, research, faculty, and a student subchapter of the American Fisheries Society.

http://www.uri.edu/cels/favs/ - University of Rhode Island, Department of Fisheries, Animal & Veterinary Science - Academic programs in aquaculture at the graduate and undergraduate level are offered.

http://www.aquaculture.stir.ac.uk/ - University of Stirling Institute of Aquaculture - "The Institute of Aquaculture is an international research and post-graduate training centre which is the largest of its kind in the world."

http://www.ksuaquaculture.org/ - Kentucky State University

http://www.msucares.com/aquaculture/index.html - Mississippi State University

http://www.agriculture.purdue.edu/arp/ - Purdue University School of Aquaculture

http://www-seafood.ucdavis.edu/ - SeafoodNIC (University of California-Davis)

http://131.230.57.1/FishWeb/CoopFish.htm - SIUC Fisheries Research and Aquaculture Demonstration Center

http://agpublications.tamu.edu/ - Texas A&M University

http://www.ait.ac.th/ - Asian Institute of Technology - Offers information about aquaculture in Asia and the Pacific area.

http://www.seafieldcentre.co.uk/ - Highland School of Aquaculture - College involved in Aquaculture training in Scotland.

http://www.nafc.ac.uk/ - North Atlantic Fisheries College - Scalloway, Shetland

http://fisheries.ege.edu.tr/ - Ege University Faculty of Fisheries - The web page of Faculty of Fisheries, Aquaculture, economics, fisheries, diseases, contact adresses, hydrobiology.

http://www.upei.ca/~fishhlth/fish.htm - Fish Health - Atlantic Veterinary College

http://www.uoguelph.ca/fishnutrition/ - Fish Nutrition Research Lab - University of Guelph. Our lab studies the nutrition of salmonid fish., This includes research on dietary nutrient and energy requirements and diet ingredient digestability in trout and salmon.

http://www2.mgccc.cc.ms.us/~aqua/ - Mississippi Gulf Coast Community College - "Aquaculture Department"

http://www.natfish.tafensw.edu.au/ - National Fishing Industry Education Centre - TAFE provides training for the aquaculture industry in Australia. You can, study at home via Internet or attend practical workshops at Grafton, NSW.

Government

US

http://ag.ansc.purdue.edu/aquanic/jsa/federal_guide/index.htm - Guide to Federal Aquaculture Programs and Services - Provides information on aquaculture-related federal programs.

http://www.reeusda.gov/agsys/adds - Agricultural Databases - A compilation of comprehensive electronic collections of peer-reviewed and expert-selected educational materials and decision aids. This site is managed by the USDA.

http://www.nal.usda.gov/aic/ - Aquaculture Information Center (AIC) - Serves as a national clearinghouse for aquaculture information by providing publications based on species and subject. This site is maintained by the USDA.

http://www.fda.gov/cvm/ - Food and Drug Administration's Center for Veterinary Medicine - Regulates the manufacture and distribution of food additives and drugs that will be given to animals. The center is part of the FDA.

http://www.mbda.gov/Virtual_Centers/Aquaculture/index.html - Minority Business Development Agency Aquaculture Virtual Center - Designed to assist minority entrepreneurs in entering the aquaculture field. It is part of the Department of Commerce, Minority Business Development Agency web.

http://www.nalusda.gov/ - National Agricultural Library (NAL) - "The National Agricultural Library (NAL), part of the Agricultural Research Service of the U.S. Department of Agriculture, is one of four National Libraries in the United States. NAL is a major international source for agriculture and related information. "

http://www.usda.gov/nass/pubs/pubs.htm - National Agricultural Statistics Service (NASS) - Fact finder for agriculture. Resource holds many government publications relating to agriculture.

http://www.nasda.org/ - National Association of State Departments of Agriculture (NASDA) - Association which represents the secretaries, directors and commissioners of agriculture in all 50 U.S. states and 4 U.S. territories.

http://www.nmfs.gov/trade/ - National Marine Fisheries Service Office of Industry and Trade - Find trade leads, current and historical trade statistics, import requirements, news flashes, and more. The Industry and Trade staff promotes and facilitate trade for the U.S. seafood and aquaculture industries by expanding existing markets and opening new ones for U.S. producers and processors.

http://www.nass.usda.gov/census/census97/aquaculture/aquaculture.htm - Aquaculture Census - 1998 - Interesting aquaculture statistics compiled by the USDA.

http://www.ustfa.org/ - U.S. Trout Farmers Association - "Oldest commercial aquaculture trade organization in the United States and is devoted to trout and salmon farming. "

http://www.usda.gov/ - United States Department of Agriculture (USDA) - Official federal government website. USDA remains committed to assisting America's farmers and ranchers.

http://ag.ansc.purdue.edu/aquanic/jsa/ - United States Joint Subcommittee on Aquaculture (JSA) - Serves as a Federal interagency coordinating group to increase the overall effectiveness and productivity of Federal aquaculture research, transfer, and

assistance programs.

http://usda.mannlib.cornell.edu/reports/erssor/livestock/ldp-aqs/ - Economic Research Service's Aquaculture Outlook - Examines the U.S. aquaculture industry: production, inventory, sales, prices, inputs, and trade of catfish, trout, tilapia, salmon, mollusks, crawfish, shrimp, ornamental fish and new species.

http://www.econ.ag.gov/ - ERS Situation and Outlook Reports - Contain over 300 reports and datasets from the economics agencies of the U.S. Department of Agriculture.

http://www.aquanic.org/ - USDA Aquaculture Site - Site with links to various USDA groups relating to Aquaculture.

http://usda.mannlib.cornell.edu/ - USDA Situation Reports - Use a search engine to browse USDA reports on various topics.

States

http://www.aloha.com/~aquacult/ - Aquaculture in Hawaii - Guide to getting started in aquaculture in Hawaii, presented by the State Aquaculture Development Program.

http://www.magnet.state.ma.us/czm/wpfishos.htm - Massachusetts Aquaculture White Paper - Fish Farms & Other Types of Aquaculture

http://www.state.ma.us/dfa/aquaculture/index.htm - Massachusetts Department of Food and Agriculture Aquaculture Division - Aquaculture is Agriculture in the Bay State. The Aquaculture program at the DFA offers a variety of services aimed at facilitating aquaculture development in Massachusetts.

http://www.agr.state.nc.us/aquacult/ - Aquaculture in North Carolina - North Carolina Department of Agriculture and Consumer Services, Division of Aquaculture and Natural Resources.

http://haywood.ces.state.nc.us/pubs/trout/ - Commercial Trout Aquaculture - Western North Carolina production factsheets are available. North Carolina Cooperative Extension

http://darc.cms.udel.edu/ - Delaware Aquaculture Resource Center - Information about aquaculture in Delaware and the Mid-Atlantic region

http://www.morrisville.edu/nysaa/index.htm - New York State Aquaculture Association Homepage - includes association and membership, information, mission statement, newsletter and document archive, and links.

http://www.ncagr.com/aquacult/ - North Carolina Aquaculture Division - "In North Carolina, farmers grow trout, catfish, hybrid striped bass, crawfish, ornamental fish, baitfish, clams and oysters. "

Sea Grant Programs

http://www.soest.hawaii.edu/SEAGRANT/ - Hawaii Sea Grant - Continues to be a leader in aquaculture, coastal processes and technology development. Among its most noteworthy past achievements are advances in ocean water quality monitoring, seaweed agronomy, prawn aquaculture, fisheries research, fisheries enhancement, precious corals and deep sea technology.

http://www.seagrant.wisc.edu/Advisory/Aquaculture/index.html - Wisconsin Sea Grant Advisory Services/Aquaculture - Aquaculture is an emerging industry of growing importance to Wisconsin, the United States, and the world. With a current estimated value of $8.8 million a year, the Wisconsin aquaculture industry is growing at an annual rate of about 11 percent.

Other Countries

http://agrolink.moa.my/ - Agrolink - Home page for Ministry of Agriculture in Malaysia.

http://www.aqkaqua.com/ - Aquaculture in Malaysia - Invest, Participate, Research, shellfish and finfish, submersible sea cages, intensive tank and pond culture, shrimps, prawns, sturgeon, tropical finfish of many species, modern technology applied and supported, skilled personnel, government and private sector contacts

http://www.mpeda.com/ - Marine Products Export Development Authority - Promotes aquaculture in India. Is the government of India's organization responsible for development of seafood industry and aquaculture.

http://www.nofa.net/aquaculture.html - Aquaculture in Norway - Provides links to aquaculture sites and info on aquaculture (biology, production).

Journals

http://www.sciencekomm.at/journals/hydro.html - Aquaculture Journals on the WWW - Directory of links to aquaculture, hydrology, marine & freshwater science journals.

http://www.joe.org/ - Journal of Extension - Peer reviewed publication of the Cooperative Extension System. It seeks to expand and update the research and knowledge base for Extension professionals and other adult educators to improve their effectiveness.

Journal of Aquaculture

Progressive Fish Culturist Journal

Journal of Aquatic Conservation

Fish Biogenics Model

Other Web Sites

http://www.aquaculturemag.com/ - Aquaculture Magazine OnLine

http://www.theaquaculturenews.com/ - Aquaculture News - Newspaper of the aquaculture industry. News items, editorials, columns, feature articles, and classifieds are included.

http://www.aquanews-directory.com/ - Aquaculture News' Internet Supplier Directory.

http://www.ecoscope.com/chosid.htm - Aquaculturist's Guide to the Net - Created by David Chosid, a student in marine sciences at the Rutgers University Cook College. He provides information about organisms, by locations and by diseases.

http://www.aquafind.com/ - Aquafind - Searchable database of producers of fish species, suppliers to the aquaculture industry, trading boards, articles, aquaculture links, market prices and more.

http://www.aquanet.mun.ca/ - AquaNet - AquaNet is the Network of Centres of Excellence for Aquaculture in Canada funded by NSERC and SSHRC through Industry Canada. AquaNet is composed of three themes; Animal Production, Environmental Integrity, and Socio-Economic Aspects.

http://www.elsevier.nl/homepage/san/aqua/online/online.sht - AQUA-Online - Elsevier Aquaculture Website. Welcome to the Elsevier aquaculture website. Your gateway for the information on aquacultural research, engineering and management.

http://www.fish-news.com/ffn.htm - Fish Farming News - Aquaculture's Business Newspaper - International circulation, encompassing all major farm raised species.

http://biosys.bre.orst.edu/crspDB/ - PD/A CRSP Aquaculture Database - The PD/A CRSP Aquaculture Database is a centralized data storage and retrieval system for aquaculture studies performed under The Pond Dynamics/Aquaculture Collaborative Research Support Program. The majorities of studies currently in the Database are for production of Nile tilapia (Oreochromis niloticus) in sub-tropical and tropical, solar algae ponds, receiving inputs of plant materials, inorganic/organic fertilizers, and/or prepared feeds.

http://www.aquanet.com/ - Aquatic Network - Information Service for the Aquatic World. Subject areas covered include aquaculture, conservation, fisheries, limnology, marine science and oceanography, maritime heritage, ocean engineering, and seafood.

http://www.naqua.com/ - Northern Aquaculture - Your Online Resource to the Cold Water Aquaculture Industry in North America. Publishers of Northern Aquaculture Newspaper and Hatchery Magazine.

http://www.tilapia.com/ - Rain Forest Aquaculture - Web site of the leading tilapia producer in the Americas.

http://aquatic.unizar.es/ - Revista AquaTIC Magazine - Online about aquaculture in Spanish

http://www.atc.stir.ac.uk/fishing/ - John Bostock's Fishing for Information - One of the premiere compilations of aquaculture related information on the internet.

Aquaculture Center's

http://www.aquaculture.com.au/ - Australian Aquaculture Centre - Australian web site dealing with aquaculture issues. Links to various resources in Australia.

http://www.rug.ac.be/aquaculture/ - Laboratory of Aquaculture & Artemia Reference Center - "Involved in interdisciplinary research on aquaculture with various laboratories of

the University of Ghent and numerous other research centers in Belgium and abroad."

http://www.maineaquaculture.org/ - Maine Aquaculture Innovation Center (MAIC) - Strategy for developing aquaculture in the state has included promoting cooperation among university and technical college researchers, industry and government personnel, and those involved in traditional fisheries and aquaculture.

http://www.aquacrc.uts.edu.au/ - Cooperative Research Centre for Aquaculture - An Australian research provider drawing on the strengths of twenty research institutions and fourteen aquaculture industry bodies.

http://www.enaca.org/ - Network of Aquaculture Centers in Asia-Pacific (NACA) - NACA's vision is to assist member governments to improve opportunities for sustainable aquaculture development and aquatic resources management to contribute to social and economic development in the Asia-Pacific region.

http://ag.ansc.purdue.edu/aquanic/ncrac/ - North Central Regional Aquaculture Center (NCRAC) - Administrative unit that serves the twelve states in the North Central Region: Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin.

http://www.umassd.edu/specialprograms/nrac/ - Northeastern Regional Aquaculture Center (NRAC) - "Headquartered at University of Massachusetts Dartmouth, develops and sponsors cooperative regional research and extension projects in support of the aquaculture industry in the northeastern United States. "

http://www.aquaculturecenter.com - Aquaculture Center Of The Florida Keys, Inc. - State of the art marine finfish hatchery.

http://www.ag.auburn.edu/dept/faa/icaae1.html - International Center for Aquaculture and Aquatic Environments - Maintained at Auburn University, aims to improve the quality of life by facilitating the sustainable development of aquatic resources requiring that social and economic needs of people be balanced with technological interventions and managerial practices that conserve the environment.

http://cahpwww.nbc.upenn.edu/html/animal.html - Center for Animal Health and Productivity - Aquaculture - Gateway to additional aquaculture resources.

http://library.kcc.hawaii.edu/CTSA - Center for Tropical and Subtropical Aquaculture - Home page of the Center for Tropical and Subtropical Aquaculture (CTSA), co-administered by University of Hawaii and The Oceanic Institute. CTSA is one of five Regional Aquaculture Centers funded by the US Dept. of Agriculture Cooperative Research, Extension and Education Service.

http://www.seafdec.org.ph/ - SEAFDEC Aquaculture Department - Southeast Asian Fisheries Development Center Aquaculture Department For Sustainable and Responsible Aquaculture.

http://www.msstate.edu/dept/srac/ - Southern Regional Aquaculture Center - SRAC is an administrative unit serving Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, Oklahoma, Puerto Rico, South Carolina, Tennessee, Texas, U.S. Virgin Islands and Virginia. , Projects developed and funded by SRAC are based on industry needs and are designed to directly impact commercial aquaculture

developments in all states and territories.

http://www.fish.washington.edu/wrac/ - Western Regional Aquaculture Center (WRAC) - Includes the states of Alaska, Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington and Wyoming. Participating universities from these states operate under a Memorandum of Understanding, which ensures joint commitment and co-equal status.

Feed

http://www.aquafeed.com/ - Aquafeed.com - Web-based resources for the aquafeed industry. Features include a monthly newsletter.

http://www.feedtech.com.my/ - FeedTech - Supplier of Malaysian cultured ornamental fish & distributor of quality aquaculture feeds, feed enrichments and equipment.

http://www.globalaquafeeds.com/ - Global AquaFeeds - Suppliers of quality feeds to the international aquaculture industry.

http://www.greenerpastures.net/ - Greener Pastures Development Corp. Inc - Certified organic algae controls, fish feeds and osmotic regulators.

http://users.skynet.be/sky39544/ - VDS animal feed - Premixes and aquaculture feed products, consult services

http://www.marbro.com/ - Martin Mills Inc. - Feed Manufacturer in Elmira, Ontario, Canada. Aquaculture feeds for Trout, Char, Tilapia, Bass, Perch, Bluegills, Koi and others.

http://www.mega-supply.com/ - MEGASUPPLY - Distributor of high quality equipment, feeds and supplies to the Aquaculture Industry.

http://www.moore-clark.com/ - Moore-Clark – Producer of high quality feeds for the aquaculture industry.

http://www.corey.nb.ca/ - Corey Feed Mills, LTD. - Located in New Brunswick, Canada, offers products that are designed to provide optimum nutritional content for all stages of fish development.

http://www.danafeed.dk/ - Offers a complete range of fish feed for trout, salmon, eel, turbot, halibut, cod and other species.

http://www.aquafauna.com/ - Bio-Marine, Inc. - World wide suppliers of aquaculture feeds, equipment and supplies.

http://www.biosoft.no/ - BioSoft AS - Safe food supply and sustainable management of aquatic resources.

http://www.bonaventure.net/ - Bonaventure Chemicals, Inc. - Feed additives for aquaculture and aquaculture products.

http://www.burrismill.com/ - Burris Mill & Feed, Inc. - Manufacturer of quality aquaculture feed.

http://www.kingdomway.com/ - Xiamen Kingdomway Vitamin Limited - The company is engaged in production and sales of Vitamin A, Vitamin D3, and Vitamin AD3 feed additives powder or oil solution of different specification and their related products.

http://www.silvercup.com/ - Nelson & Sons, Inc. - Manufacture Sterling Silver Cup Fish Feed.

http://www.oceanbiosource.com/ - Ocean Biosource Inc. - Creates protein products for the aqua feed ,animal feed, and organic fertilizer markets.

http://www.aquafeeds.com/ - Cargill Aquafeed - An international supplier of quality aquaculture feeds.

http://www.rangen.com/rangen006.htm - Rangen, Inc. - Aquaculture Division is recognized as an international leader in the production of feeds and feed additives for aquaculture.

http://www.a-saltcrk.com/ - Salt Creek, Inc & Microfeast: Produces feeds for Aquaculture.

http://www.zeiglerfeed.com/ - Zeigler feed – Produces aquaculture feeds.

http://www.taplow.com - Taplow feed – Produces trout feeds.

Equipment

http://www.aquanet.com/www/airlake.htm - Airlake Aeration Systems Inc. - Manufactures and markets aeration equipment for the aquaculture industry.

http://www.aquanetics.com/ - - Aquanetics Systems Inc., located in San Diego, is a manufacturer and supplier of filter systems, pumps, chillers, heaters, and aeration equipment for aquaculture. They also design, engineer, and build complete systems for commercial aquaculture operations, educational facilities, and aquatic research laboratories.

http://www.aquadyne.com/ - Aquadyne Computer Corp. - Manufacturers of water quality instrumentation and remote communication accessories.

http://www.aquasales.com/ - Aquaculture Supply – Sells wide variety of aquaculture supplies.

http://www.ozemail.com.au/~aquasys/ - Aquaculture Systems Pty Ltd - Australia's leading manufacturer of intensive aquaculture equipment. Modular systems for production of fin fish, eels, lobster, prawns, and many other species groups.

http://www.beadfilters.com/ - Aquaculture Systems Technologies LLC - (AST) Sells "Propeller-Washed Bead Filters" and "Bubble-Washed Bead Filters" for re-circulating aquaculture systems, research facilities, commercial aquariums, and aquaculture

education.

http://members.magnet.at/aquaculture/ - Aquaculture Technology – Sells aquaculture equipment; Also offers consulting.

http://www.heymann-aquaculture.com/aqualor/uk/index.htm - Aqualor - Equipment and products for fish farming and aquaculture. Located in France.

http://www.aqua-manna.com/ - Aqua-Manna Inc. - Designs and manufactures high quality equipment for re-circulating aquaculture systems . Aqua-Manna also raises Tilapia and sets up individual growers into Aqua-Manna's strategic partnerships.

http://aquaneering.com/ - Aquaneering Inc. - Design, manufacture, and supply equipment for aquaculture. Specializing in aluminum live haul tanks and fluidized bed re-circulating systems.

http://www.eutechinst.com/ - Eutech Instruments Pte Ltd - Manufacturer of water quality testing instruments. pH meters, TDS/Conductivity, meters, ORP meters, dissolved oxygen meters etc.

http://www.feeding-systems.com/ - Feeding Systems - Feeding Systems AS produces state-of-the-art fish farms complete with cages, feed barges and feeding systems.

http://www.filtomat.com/ - Filtomat, Inc - International Manufactures of self-cleaning filtration equipment with aquaculture experience.

http://www.fishmore.on.ca/ - Fishmore Inc. - Manufactures equipment for the seafood and aquaculture industries.

http://www.freshflo.com/ - Fresh-Flo Corporation - Manufacturer of water aerators and fish graders supplying the aquaculture industry for over 30 years. Also makes an adjustable fish grader.

http://www.fwfarms.com/ - Freshwater Farms of Ohio, Inc. - Offers live fish for purchase and fish farm/pond equipment.

http://www.growfish.com/ - Global Aquatics - Aquaculture Equipment and Services. Aquaculture engineers and consultants world wide. Designers of the S-99 "Steel Core" raceway tank systems.

http://www2.cconnect.net/lanceind/ - GRADE-RIGHT Aquaculture - Stop chasing fish with a dip net! GRADE-RIGHT™ Aquaculture Grading/Harvesting Systems can help commercial producers increase profits and researchers or government hatcheries improve productivity on limited budgets with systems developed for raceways and tanks, for a variety of species.

http://www.greenaqua.com/ - GreenAqua Ltd. - Environmentally safe aquaculture, technologies, products and services.

http://www.vmgindustries.com/ - VMG Industries - Manufacturer of “Van Gaalen Fish Egg Sorter” and oxygenation injection equipment.

http://www.spencerturbine.com/Vortex/main_vortex.html - Vortex Regenerative Blowers for pond or large tank aeration.

http://www.a1aquaculture.com/ - A-1 AQUACULTURE –Manufactures the continuous cleaning multi-functional biofilter.

http://www.aireo2.com/ - Aeration Industries International, Inc. - Supplier of aeration equipment for a wide variety of applications including aquaculture.

http://www.aqion-usa.com/ - Aqion - Suppliers to global aquaculture

http://www.allproducts.com.tw/machine/pioneer/ - Pioneer A.E. Company Limited - main business is in the field of Aquaculture. Major products and services are: (1) Aquaculture Equipment : Paddlewheel Aerator, Air-Injector, Automatic Feeder, and Pump. (2) Whole Plant Project : Feed-Mill, Processing Plant.(3) HDPE Pond Liner : Installation advised by qualified & licensed Geo-Technician. (4) Marine Net Cage System. (5) Aquaculture Consultant Services, etc.

http://www.pointfour.com/ - Point Four Systems - Manufacturer for aquaculture, fish farming industry of oxygen monitoring, diffuser equipment and specializes in the design and supply.

http://www.praqua.com/ - PRAqua Technologies Ltd - Aquaculture Recirculation Systems

http://perso.wanadoo.fr/proaqua/ - PRO AQUA: Shrimp & Fish Farming Equipment - Supply of equipment for fish and shrimp farming - Tank design and construction - All chemicals - Pumping stations etc.

http://www.areainc.com/ - AREA (Aquaculture Research/Environmental Associates, Inc.). - Design and sale of aeration and water heating/chilling systems.

http://www.argent-labs.com/ - Argent Chemical Laboratories - Aquaculture company specialized in fish medicine, feeds, books, and equipment.

http://www.megafisch.de/ - MEGA FISCH Germany - Mega Fisch is renowned for their excellent service and supply in all aspects of modern and super intensive aquaculture systems

http://www.multivis.nl/ - Multivis - Provides equipment for waste water treatment and aquaculture.

http://www.bumpkinland.com/aquacad/ - AquaCAD Pond Design Software - If your in the aquaculture, pond construction, or land grading business, own a fish farm, you need AquaCAD.

http://www.chaqua.com/ - C+H Aquaculture - Fish farming equipment and systems. Scottish based manufacturers of feeding systems, fish pumps, oxygen injection units and oxygen monitoring systems. Also supply complete range of a general equipment.

http://www.cittadini.it/ - Cittadini Spa - Cittadini Spa is a world leader in the manufacturing of fishing nets and ropes.

http://www.clearcatch.com/ - Clear Catch Nets - Designed and tested to virtually disappear when immersed in water.

http://www.coastalaquacultural.com/ - Coastal Aquacultural Supply - Shellfish and finfish aquaculture equipment.

http://www.columbia.w1.com/ - Columbia Fiberglass - Manufactures aquaculture tanks, raceways, and transport tanks.

http://www.commercewelding.com/ - Commerce Welding and Mfg. Co., Inc. - Manufacturer of the Mino-Saver Product Line. Aerators and agitators, fish grader boxes and baskets.

http://biosys.bre.orst.edu/aquacult/aquasoft.htm - Computer Tools - For aquaculture management and design. Maintained by the Bioresource Engineering at Oregon State University. This site reviews various aquaculture computer programs.

http://www.fish2o.net/default.htm - Continental Eagle Corp. - Produces the FisH2O aerator.

http://www.cottonpickerworks.com/ - Cotton Picker Works - Farm pond aerators.

http://www.diagxotics.com/ - DiagXotics Inc. - Diagxotics provides disease diagnostic test kits to the aquaculture farming industry.

http://www.ednet.co.uk/~dryden Dryden Aqua - Manufacturers of intensive commercial recirculation systems, UVc disinfection, ozonation, pressures sand filters with new AFM (Advanced Filtration Media) as opposed to sand.

http://www.bigjohnaerators.com/ - Big John Aerators – Manufactures aerators available for all aquaculture needs.

http://www.biohero.com/aqua_ecomarine.html - Bio Solutions - EcoMarine concentrated bacteria tablet provides effective solutions to problems which threatens aquaculture and the environment.

http://www.hach.com/ - Hach Chemical Company - Supplier of test kits and methods for water quality testing

http://www.hiqbio.com/ - Hi-Q Bio-Tech International Ltd. -. Located in Taiwan and China. Supply aquaculture application services and provide the Zero Water Exchange system. Using their bio filter and natural Chinese herbs, they changed damaging water into nutrition that fish need. Said to have increased crop density by 5 to 20 times.

http://www.housemfg.com/ - House Manufacturing Company, Inc - Specializes in aerators, portable pumps, fish feeders, and electric control panels.

http://www.hschem.com/aquacheck/ - AquaCheck Systems, Inc. - Manufacturer of colorimeters for water testing. Water test kits and chemical reagents.

http://www.keetonaqua.com/ - Aquaculture by Keeton Industries, Inc. - Fish farming and other aquacultural equipment and supplies distributor. Consulting services and water quality testing also provided.

http://www.ncraft.com.au/ - Netcraft Pty Ltd - Supplier of aquaculture and agriculture netting.

http://www.novatlantique.fr/ - NOVATLANTIQUE : Aquaculture Management Software for fish and shrimp farming Available in English, Spanish, Turkish and French.

http://www.opposingflowstech.com/ - Opposing Flows Technology – produces opposing flow systems.

http://www.orbeco.com/ - Orbeco Analytical Systems, Inc. - Manufacturer of portable and laboratory water quality instruments and test kits for fresh and saltwater analysis.

http://www.generalcybernetics.com/products.htm - OxBox Dissolved Oxygen Meter - The OxBox is a rugged, field-worthy dissolved oxygen analyzer for the aquaculture industry. It is capable of taking fast, accurate readings and has the ability to record, store and display readings for up to 60 ponds.

http://www.oxair.com/ - Oxygen Generator Manufacturer - Designs and manufacturers of on-site oxygen generating equipment for military, medical, and industrial applications.

http://www.oxyguard.dk/ - OxyGuard - OxyGuard manufactures equipment for the measuring of dissolved oxygen, pH, ORP/redox in aquaculture

http://www.oxymat.dk/ - Oxymat Oxygen Generator Systems A/S - Danish manufacture of PSA oxygen generators, oxygen diffusers, oxygen monitor and oontrol systems, and oxygen injection systems.

http://www.ozoneapplications.com/ - Ozone Solutions, Inc. - Injecting ozone into fish farms to improve water quality. Benefits are reduced disease loads, clearer water, reduced organics, and higher DO levels.

http://www.imetronic.com/self-feeder.html - Imetronic - Creates and manufactures automatic apparatus for behavior studies in neurobiology and pharmacology research. With a good knowledge in animal behavior and in automatisms, and with the collaboration of a research laboratory (INRA: T.Boujard), they have developed an automatic self-feeder for fish especially designed to make precise studies on fish behavior.

http://www.jbcsafety.com/ - JBC Safety Plastics Inc. - Manufacturers of paddle wheel aerators and other equipment.

http://www.kascomarine.com/ - Kasco Marine Inc. – Produces Aerators.

http://www.tecinfo.com/~aqcenter/ - Aquacenter - Full service supplier for fish & lake management supplies located in Leland, Mississippi.

http://www.respirometer.com/ - Respirometer - O2/CO2 Respirometers for measuring oxygen, consumption of fish, algae, scallop, and bacteria. Can be also used to measure respiration of cell and tissue culture.

http://www.simar.cl/ - SIMAR - Aquaculture and fish farming equipment.

http://www.singlechips.com/ - SingleChips Aquaculture Remote Monitoring and Control - Industrial strength aquaculture monitoring and control equipment, for warm water re-

circulating systems.

http://www.suncoastsys.com/ - Suncoast Systems, Inc. – produces Oscar, which stands for 'Oxygen Scan, Control, Alarm and Report, a fish monitoring system.

http://www.technika.com/ - Technika - Manufacturers of various water quality and measurement instruments.

http://www.thepowerhouseinc.com/ - The Power House Inc. – Manufactures top of the line Aerators, Fountains, and the Ice Eater for ice prevention.

http://www.w-m-t.com/ - Water Management Technologies, Inc. - WMT carries a full line of equipment to satisfy a variety of water quality concerns. Whether you are installing a new system or upgrading an old one, our engineers will provide solutions that work.

http://www.ysi.com/ - Yellow Springs Instruments, Inc (YSI) - Designs and manufactures precision measurement sensors and control instruments for users around the world.

http://www.zellastrading.com/ - ZELLAS TRADING COMPANY - Specializes in sales of machinery and equipment for the aquaculture industry.

Services

http://www.tilapiaseed.com/ - Aquasafra, Inc. - Specialize in providing quality hybrid tilapia fingerlings and broodstocks to the industry.

http://aquacare.com/ - Aquacare Controlled Environment Aquaculture Technology - Specializes in intensive land-based controlled environment aquaculture systems. Aquacare can develop, design and supply complete fish farms for clients worldwide.

http://members.tripod.com/jbstewart0/index.htm - Aquaculture Consultant - John Stewart - Senior Manager with Global insight.

http://www.ennix.com/ - Ennix Incorporated - supplies biotechnology to support aquaculture, agriculture, municipal waste, and more.

http://fis.com/ - Fish Info Service (FIS) - Free access information site for aquaculture, seafood and fisheries. Multilingual site has fish prices, market reports, hot news, trading market plus much more.

http://www.fishofthefuture.org/ - Fish of the Future, LLC - International consultants of aquaculture. Specializing in tilapia and re-circulating systems.

http://www.ftai.com/ - Fisheries Technology Associates, Inc. - Aquaculture consulting and fisheries consulting services company. Feasibility studies, designs, construction oversight, facility start-up, and management by Bill Manci.

http://www.aquatecon.de/ - Fishfarming equipment - 1. Consulting for fish farmers 2. Supplier for re-circulated systems 3. Business plans.

http://www.fishlink.com/ - FISHLINK - One-stop shop for aquaculture and fisheries on the web.

http://www.mountainmenu.com/freshwater/ - Freshwater aquaculture consulting.

http://www.fsvo.com/aquaculture/ - Freshwater Solutions - Consultants and designers for sustainable organic aquaculture.

http://www.members.tripod.com/jimmyaolim - Venture Farms Pte Ltd - Aquaculture consulting in shrimp and marine fish.

http://www.acdivoca.org/ - ACDI/VOCA - -Private, nonprofit international development organization providing high-quality technical expertise at the request of farmers, agribusinesses, cooperatives, and private and government agencies abroad.

http://www.advancedaquaculture.com/aquaculture/ - Advanced Aquaculture Systems, Inc. – Specialize in the design of energy efficient recirculation and ponds systems using proprietary components and systems designs. Offer free systems design services for all types and sizes of filtration and aeration systems.

http://www.amaqua.com/ - Amaqua- The American Aquaculture Corporation - Specialists in aquaculture and marine shrimp farming, can provide world-wide consultancy for new start-ups as well as assist on-going operations.

http://www.ampventures.co.za/ - AMP Ventures - Aquaculture development, marketing of African fish products, financial solutions and quality assurance plans for new and current ventures.

http://www.antecint.com/ - Antec International - Leaders in Biosecurity. Complete information about biosecurity and hygiene programs for farm horticulture and aquaculture.

http://www.appliedaquatics.com/ - Applied Aquatics, Inc. - Professional aquacultural engineering and consulting firm. Provide systems and facilitlies design as well as independent equipment sales.

http://www.aquahabitat.com/ - A Natural Pond Designed by Biologists - Biologists who design all natural ponds. Ponds, lakes, streams, design, construction, management, planning. Swimming ponds, fish ponds, fishing ponds, trout ponds.

http://www.aquanet.com/pdm/ - P. D. M. & Associates - Innovative Solutions for the Aquaculture Industry. Aquaculture consulting and special feeds.

http://www.fishfarming.com/ - AquaSol, Inc. - Affiliated group of consultants providing technical expertise to new or existing aquaculture operations. Our specialty is project management for marine shrimp and tilapia farming operations in Latin America.

http://www.adsi.com.au/ - Aquatic Diagnostic Services International Pty Ltd - Addressing the needs for a fast, accurate veterinary diagnostic service for the aquaculture industry. Also developed and distribute a wide range of aquaculture therapeutics and diets.

http://www.keetonaquatics.com/ - Aquatic Solutions by Keeton Industries, Inc. - Consulting, design and building supplies for ponds and lakes. Alternative power aeration systems, filters, liners, microbes, chemicals and more.

http://www.aquatictech.net/ - Aquatic Technologies, Inc. - World wide aquaculture engineers and consultants. Turn key intensive aquaculture specialists.

http://www.aftm.homestead.com/ - Asian Fisheries Technology and Management co. ltd. - An Indo-Iranian organization offering technical services to the aquaculture units such as farms, hatcheries, processing, centers, and so on.

http://www.aquatechgroup.com/ - Aqua Technologies Group, Inc. - Research Company for industrialized aquaculture, specializing in marine fish breeding, hatchery, and grow-out production. Offering consultation and joint venture.

http://www.mindspring.com/~jymevel/ - MACS - Mevel Aquaculture Consulting Service, Inc.

http://www.biocepts.com/ - BioCepts International, Inc. - Wide assortment of professional biotechnology services related to the aquaculture (food and ornamental species) industry, ranging from production facility site selection, facility and product design, product development, product evaluation, applied research, technology audits, aquaculture product market studies, complete health management plans, and disease prevention.

http://www.masgc.org/director/costapierce.htm - Home page of Barry Costa - Pierce, International Fisheries & Aquaculture Consultant

http://www.hydrologica.com/ - Hydrologica Aquaculture Consultancy - Tilapia-Hydrologica Consultants. Hydrologica provides to customers state-of-the-art aquaculture technology, especially in tilapia and shrimp production systems. Hydrologica gives technical support for 20 aquaculture projects in Brazil, Mexico, Norway and USA.

http://www.nautilus-consultants.co.uk/ - Nautilus Consultants Ltd. - Natural resource economists based in Edinburgh, Scotland. Nautilus is an international management consultancy specializing in the economic, commercial and environmental dimensions of natural resource use. Considerable experience in tropical and temperate aquaculture and fisheries planning.

http://www.noe-aquaculture.com/ - Noe Aquaculture Consultants - Consultancy in tropical aquaculture. Shrimp and tilapia farming. Aquaculture projects management. Provisioning of shrimp and tilapia for export. Seafood quality control.

http://www.northernlakeservice.com/ - Northern Lake Service Inc. - Environmental analytical laboratory offering water quality studies, wastewater analyses, fish tissue analyses for the aquaculture industry. Analyses for metals, nutrients, inorganic/organics.

http://www.proaxis.com/~sleeter/ - Achieve Aquaculture -Aquaculture consulting with experience worldwide

http://www3.nf.sympatico.ca/hmurphy/ - Industry Support Services Inc. - A home based company proving Consulting and Development Support services to a wide range of Fisheries , Environment and Aquaculture Activities. Location St. John's Newfoundland, Canada.

http://www.infraspect.com/ - Infraspect Environmental Sciences & Community - provides educational services and technical performance audits concerning aquaculture industry and agency level management pertaining to the ecosystem approach & sustainable

development.

http://www.fishindia.com/ - Indian Centre For Aquaculture and Fisheries Trade - Aquaculture Joint-Ventures, Consultancy, Research & Development, Marketing, Seafood supply, Aquaculture equipment designing, Fish & Fishery product trading and all aquaculture related activities.

http://www.aquaculture.co.uk/ - Insurance, Risk Management and Financial Services for Aquaculture - For commercial aquaculture businesses that want to protect their investments in the industry. The site lists contacts amongst Insurance Companies, Brokers and Agents, Loss Adjusters, Risk Management Surveyors, and others involved in insuring and risk managing aquaculture.

http://www.iacdirectory.com/ - International Aquaculture Directory - host a complete directory of services and products for the entire industry worldwide. Also offer an "Aquaculture Engineering Tool" available through the site, which will help design and give calculations for your filtration system.

http://www.intlaquatic.com/ - International Aquatic Consultants, Inc. – Re-circulating systems and aquaculture effluent treatment. Turnkey and design/build systems. Engineering and site analysis.

http://www.iol.ie/~gac/ - International Fisheries, Aquaculture and Seafood Consulting Services - Galway Aqua Consulting Ltd is a firm of Consulting Aquaculturists, providing a wide range of services in fish related activities comprising fish farming, processing and marketing. This firm is located in Ireland.

http://hometown.aol.com/kuupauco/myhomepage/business.html - Ku'upau Consulting - Specialist aquaculture and feed marketing, publicity, editorial and technical services.

http://www.dec.state.ny.us/website/education/rogrctr.html - Rogers Environmental Services - Aquacultural and Environmental Engineering Consulting Services

http://www.fishace.demon.co.uk/ - Sustainable Organic Aquaculture - Commercial site promoting sustainable methods of aquaculture.

APPENDIX I: Work Pla

Tasks	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7
Orientation to Agency	Meet Liaison and Introduce Ourselves to INCOPESCA						Thank Sponsor for Time and Help
Orientation to Costa Rica	Spanish Classes	Spanish Classes					
Surveying	Determine Issues that Should be Included	Formalize Questionnaire Design	Finalize Survey and Distribute Final Surveys		Receive and Evaluate Survey Results		
Interviews	Meet People and Find Good Contacts	Create Interview Protocol Schedule Interviews	Conduct Interviews With Extension Agents	Conduct Interviews With Aquaculturists	Evaluate Interview Results		
Direct Observation	Locate Possible Contacts	Schedule Tours	Observe Sites	Observe Sites			
Project Report Writing		Revise Work Plan for Project Begin Executive Summary Draft Introduction\ Draft Outline	Revise Background and Methodology Sections		Draft References, Appendices, Abstract, Results, Analysis	Complete Project Draft	Complete Final Project
Oral Presentation						Outline Project Presentation, Practice	Practice, Final Project Presentation
Logbook	Adam L.	Walt J.	Dave G.	Adam L.	Walt J.	Dave G.	Adam L.
Weekly Meetings	Advisor Meeting, Liaison Meeting	Advisor Meeting, Liaison Meeting	Advisor Meeting, Liaison Meeting	Advisor Meeting, Liaison Meeting	Advisor Meeting, Liaison Meeting	Advisor Meeting, Liaison Meeting	Advisor Meeting, Liaison Meeting

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