Survey of Tilapia-Shrimp Polyculture in Mexico and Honduras

Tenth Work Plan, New Aquaculture Systems/New Species Research 3C (10NSR3C)/Experiment/Mexico
Final Report

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Abstract

The majority of the Mexican shrimp farming industry is situated in the Northwest of Mexico. However, shrimp aquaculture in Mexico is in crisis due to a mix of the depressed world shrimp market and disease outbreaks causing decreased yields (Panorama Acuícola, 2002).

To determine the potential for shrimp-tilapia polyculture in the area, we conducted surveys in the State of Sinaloa -the most important shrimp aquaculture area in Mexico. We visited 63 farms, which represent 63.5 % of the total number of farms in the Northwest. Four of those farms were closed for inactivity (6.35%) and ten did not respond to the survey (15.3%). We visited 22 farms in the municipality of Guasave (45% of the total surveyed). Guasave is the most important area in the State for shrimp culture.

The data collected showed that farm size varies considerably (from 9 to 1,000 hectares). The production varies from 1 to 2,300 ton/year. Most farms (52%) produce shrimp in two cycles per year (January-June and July-December). Twenty-three farms (46%) reported a single cycle per year (January-June) and one farmer claims to be able to produce shrimp in three cycles a year (2%).

All farmers use PL12 postlarvae to stock their ponds. The cost of 1,000 postlarvae in Sinaloa ranges between 5.5 to 6.5 USD. Most farms (67%) report culture cycles of 120 days and 33% of the farms report cycles of 150 days. The density used to stock ponds varies from 5 to 40 shrimp/m^2, but most farms stock between 10 and 20 shrimp/ m^2 (56.9%). The average weight of shrimp harvested in the farms surveyed is 18.0 g ranging from 7 to 35 g; however, the most common weight of shrimps falls between 15 to 25 g (58.4%). The size of the shrimp harvested is directly related to the density used to stock the ponds.

In this area, common practices for pond management are sun drying of the drained ponds, mechanical raking of the mud, lime application and slow filling with filtered seawater (98%). Most farmers (62%) use disinfectants before lime application. The most commonly used disinfectants are bleach and iodine, while other chemicals are used occasionally. Pond fertilization is not frequently practiced (24% of cases). Seawater is the main source of water for refilling and water exchange because freshwater sources are not available in the region; therefore, water exchange is seldom or not practiced at all and salinity generally increases. One respondent reported salinity values over 50 ppt.

The main cause of low yields was the white spot disease and the Taura syndrome. These diseases accounted for 73 and 65% of the reported production losses. Other important problems are bacterial diseases (50%); fungal (24%) and parasite infections (15%). Low yields, combined with a low world price for shrimp have pushed many farms into a situation where they are no longer profitable.

The results from the survey also show that 81% of the shrimp farms experienced production problems and many of these farms are considering alternative aquaculture species as an opportunity to stabilize production. Tilapia culture in shrimp ponds is being considered by 71% of the farmers. Three farms reported that they had tilapia in some of their ponds. However, none of the farmers reported any significant benefits or problems from the tilapia. The tilapia stocked were of unknown origin and were reported to be gray. This implies that they were not one of the red strains, which have been selected for salt tolerance. The two main constraints in Mexico for the development of tilapia as an alternative species for culture in shrimp ponds are knowledge of the biotechnologies required for culture in seawater and supply of seed of salinity tolerant strains of tilapia. This is a unique opportunity to continue harnessing the strengths of Aquaculture CRSP expertise and aid the development of a sustainable aquaculture system that would both safe- guard the jobs of many local inhabitants and provide work to low-income fishermen in coastal areas.

The majority of the disease outbreaks have been observed during the summer rainy season (July – October).

The rains cause large environmental fluctuations in salinity, temperature and turbidity. It is suspected that these environmental fluctuations stress the shrimps and trigger disease outbreaks. In the past 1-2 years, a number of farmers operated for just one cycle, stocking at low densities after the short winter rainy season (December-February) and harvesting before the start of the

summer rainy season (July-October). This is a longer production cycle and larger shrimps were harvested giving good yields per hectare. Although this system enables these farms to continue operating, they are not fully utilizing the shrimp ponds, which are being abandoned for a good part of the year. This results in a seasonal job market for many of the local people or even the people operating the social cooperative farms. It is considered that tilapia would be well suited to culture during this part of the year when ponds are not being used. Lower salinities associated with the rain would favor tilapia culture. Tilapia and low densities of shrimp could be stocked at the start of the summer rainy season in lower salinities and cultured through to December for Christmas markets. The combination of one shrimp cycle and one cycle of tilapia-shrimp polyculture using the culture system developed in collaboration between researchers and industry in the CRSP project would help the social cooperatives operate throughout the year giving a higher financial return from the infrastructure and providing fuller employment for the cooperatives and other local people.

The project also reviewed anecdotal reports of tilapia-shrimp polycultures in Honduras. On further investigation we were unable to find any actual instances where farms had implemented any commercial applications or even experiments. Apparently, all farmers are waiting for published reports and recommendations before they attempt such a change in their culture systems.

INTRODUCTION

Shrimp ponds have been abandoned in many parts of the world due to diseases, poor management and environmental degradation. Tilapia production, supplemented with low densities of shrimp, in abandoned shrimp ponds may provide an opportunity to develop a sustainable aquaculture system that will support local inhabitants who have not benefited from the shrimp boom in many parts of the world. Polyculture or crop rotation of shrimp and tilapia may even be the modern equivalent of the Chinese polyculture of carp. Tilapia production in former shrimp ponds (with and without shrimp) has increased rapidly in many of the Aquaculture CRSP locations including Thailand, the Philippines, Mexico, Peru, and the inland desert of Arizona.

Shrimp aquaculture has been devastated in many countries due to a mix of disease outbreaks and decreasing yields. The progression of shrimp aquaculture has followed a familiar pattern throughout the tropics. Initially, farms are constructed in the most appropriate areas. These locations are characterized by good soils with proper pH, appropriate levels of clay, silt and sand, proper elevation, good access to clean water and convenient disposal of waste waters to a location which keeps wastes from being cycled back into the farm. These farms, if managed well, tend to be very profitable. This early success leads others to imitate the process as best they can. This has led to a "gold rush" attitude where excessive numbers of farms are built, often in ecologically fragile areas, especially mangrove forests. From a practical point mangrove forests, in general, are poor sites for shrimp farms. They do not have the proper soils, there is usually poor access to water, inadequate drainage due to low elevation and they are especially susceptible to storm damage.

A related phenomenon is overstocking of an existing farm. After the initial success of a farm, the managers often assume they can increase yields and profits by stocking more shrimp and feeding more heavily. This may work for one or two crops, encouraging even more stocking. But inevitably, the producer overshoots and a disease outbreak occurs because the animals have been overstocked and are stressed under the available environmental conditions in the pond. In most cases, the farm managers react by increasing water flow through the farm or adding mechanical aeration. These do in fact address the problem but also increase operating expenses and environmental impacts. Added to this situation is the fact that the ponds must be properly maintained and the pond soils managed between crops. Many farms do not properly maintain their infrastructure or their pond environments. When multiple farms in one area reach this stage, there tends to be an environmental overload. The effluent from one farm becomes the supply water for another, the receiving environment cannot process the nutrient rich effluents, leading to eutrophication, and diseases are spread by water transfers, birds, and other vectors. Excessive pumping of water can lead to saltwater intrusion and depletion of freshwater aquifers. Farms that had been wildly profitable with little management, suddenly require more investment and sophisticated management for lower levels of profit. Some farms make the investment to operate in a more sophisticated and sustainable manner, many others just abandon the farm. In many countries the governmental oversight, environmental regulation and protection have been inadequate to avoid this serious ecological damage.

A related problem has been one of land tenure. In many instances investment groups have come in and gained control of coastal lands and hired local inhabitants. These people are usually happy to have the employment and appreciate the infrastructure (roads and electrification) which often accompany the farm. However, when these farms fail, the local inhabitants are often left with no jobs and environmental damages that impair their abilities to return to artisanal fishing or small-scale agriculture. Common environmental damages include salinization of soils, salt-water intrusion, loss of breeding areas for marine species, eutrophication, and changes in the water flow through estuaries

One technique that has been tested to utilize abandoned shrimp ponds is to convert the pond to tilapia production. There have been several variations of tilapia production including rearing in seawater, brackish water and freshwater. Some have attempted polyculture with shrimp and some are using a crop rotation of tilapia and shrimp (Fitzsimmons 2001).

In nature, tilapia are omnivores. Young tilapia graze on algal and bacteria films scraping most hard surfaces with tongue and teeth. As they grow they also become effective filter feeders of phytoplankton and predators of zooplankton. Larger tilapia are less effective filter feeders but begin to graze heavily on macrophytic algae and aquatic plants. In extensive farming situations, tilapia filter feed on algae, prey of zooplankton and scrape films from any hard surfaces in the pond. In intensive farms, most nutrition is derived from pelleted feeds, although fish will continue to spend time scraping algal and bacterial films from all surfaces.

In nature, shrimp feed first on phytoplankton and then zooplankton during larval stages. As juveniles and adults they are omnivores and detritovores. Their natural behavior is to search the bottom substrates for decaying plant and animal material. They also constantly pick up sand grains and pieces of organic matter and graze off the algae and bacteria, drop the grain or particle and go onto the next item. In farmed settings shrimp feed on pellets and natural productivity in the pond. Research by Samocha et al. (1998), has demonstrated that shrimp can be reared in systems with little water exchange, taking advantage of the natural abilities of shrimp to thrive in conditions with high bacterial loading so long as dissolved oxygen levels and other water quality factors are maintained.

There are several variations of tilapia-shrimp polycultures; simultaneous, sequential and crop rotation. In the simultaneous instance the fish and shrimp are grown together in a pond or raceway, in the sequential case the water is moved from one growing unit to another, and the crop rotation alternated tilapia and shrimp. There appear to be distinct advantages with each of these systems.

In a polyculture setting, tilapia and shrimp can utilize different niches in the culture setting. In an extensive farm, tilapia can filter feed on phytoplankton and zooplankton in the upper water column. Shrimp spend most of the time in the pond bottom grazing on bacterial films on the bottom substrate and on the detritus settling from above. This detrital matter consists of dying algae cells and fecal matter from the tilapia. In a more intensive farm receiving pelleted feeds, the tilapia monopolize the feed, especially if it is a floating feed. However, some feed particles always get to the bottom where the shrimp will get it. More importantly, the fecal matter from the tilapia contributes to the detrital rain that supports the shrimp. *Macrobrachium*-tilapia polyculture reduces the yield of prawns compared to monoculture, but increases total yield of fish and prawns (Garcia-Perez et al. 2000). A similar effect occurs with brackish water polyculture of tilapia and shrimp (Yap, 2001). Anggawa (1999) reported that yields of shrimp increased when tilapia were stocked into existing shrimp ponds. The suggested stocking rate was 20-25 g fish/m^2 and the fish size at stocking of 50-100 g/fish. The use of all-male fish was needed to control reproduction. Fish were stocked when the shrimp biomass was at least 80 g/m^2 (for 3-4 g shrimp) or 150 g/ m^2 (for 5-6 g shrimp). Tilapia harvest biomass was 40-50 g/ m^2 and shrimp survival was 70%.

From the disease aspect, tilapia seem to provide advantages in several ways. Growers in Ecuador have reported that tilapia will consume dead or moribund shrimp in polycultured ponds. Cannibalism is one of the primary vectors for transmission of shrimp diseases. Tilapia, which do not appear to be susceptible or carriers of these viruses, disrupt cannibalism as a mode of transmission. Tilapia also consume small crustaceans in shrimp ponds. These crustaceans are of concern as potential vectors. Having tilapia directly in the ponds or alternating with shrimp in a crop rotation can be effective for reducing crustacean populations. Bacterial infections also may be impacted by polyculture. *Vibrio* and most other bacterial pathogens common in shrimp culture are gram negative while waters which have been used for fish culture tend to be predominated by gram positive bacteria. Using water from a fish culture pond seems to reduce the prevalence of luminous *Vibrio* bacterial infections in shrimp ponds (Yap, 2001). Growers in Asia and South America have provided anecdotal reports that shrimp production increases due to higher survival in some of these polyculture systems, however, carefully controlled and replicated trials are needed to better study these systems and confirm the results.

Table 1. Municipalities covered by the survey.

Municipalities	Number of Farms Visited
Angostura	2
Culiacán	9
Esuinapa	4
Guasave	22
Los Mochis	17
Mazatlán	3
Rosario	6
Total	**63**

There may also be physical factors that improve shrimp survival and growth in polyculture and crop rotations. Tilapia disturb bottom sediments to a greater degree than shrimp, both in foraging and nest building activities. This may be beneficial in several ways. Disturbing the bottom could improve oxidation of the substrate and interrupt life cycles of shrimp pathogens and parasites. It could also release nutrients into the water column that could improve algae blooms. However, it is also possible that these activities may be detrimental. Disturbing bottom sediments could also negatively impact water quality, lowering dissolved oxygen levels, increasing turbidity from sediments and reducing algae blooms, ability to remove fish and shrimp, and most certainly increase the need to repair pond bottoms between crops. This particular aspect would require close attention and careful experimentation to gain a clear understanding.

METHODS AND MATERIALS

Data and information were collected through personal interviews using a prepared questionnaire. Sixty-three farms from seven municipalities of the State of Sinaloa were visited. The survey questionnaire was divided into several parts as follows:

A. Background information, which included personal circumstances of respondents such as name, length of experience in shrimp-fish polyculture and motivation for shifting into shrimp-fish polyculture.
B. Farm profile, which included information about the farm such as area, source of water, depth of ponds, salinity of the water, sources and cost of acquiring stocks
C. Production technology practiced by the respondents regarding the use of fish in shrimp ponds.
D. Pond and water management, which included questions on how ponds are prepared and whether chemicals are used or not.
E. Feeds and feeding management.
F. Parasites and disease problems.
G. Harvesting and marketing.
H. Problems encountered and other pertinent information.

Figure 1. Geographical location of Sinaloa State in Mexico. Municipalities where farmers were surveyed are: 001 Los Mochis; 002 Angostura; 011 Guasave; 018 Navolato; 006 Culiacan; 008 Elota; 016 San Ignacio; 012 Mazatlan; 014 Rosario; 009 Escuinapa.

Data gathered were collated and tabulated. Analyses of the data were mainly descriptive in nature such as frequency distribution, percentages, ranges and mean values.

Shrimp-Fish Production Practices by Municipalities

General Profile
From the 63 farms visited, information was obtained from 49 farms, four were inactive and no information was gathered from ten. All farms are located in the Pacific Ocean coastline –an area known as Mar de Cortés. This study was conducted in the State of Sinaloa because it is the most important State for Shrimp production in Mexico. Farms visited are located in seven municipalities of the State (Figure 1). Twenty two of the farms are located in Guasave and seventeen in Los Mochis (Table 1).

Feeding and Fertilization Regimes
All surveyed farms use commercial feeds exclusively. The two main brands used are Purina® and Censone®. Changes of food sizes and feeding regimes are conducted as indicated by the food manufacturers and according to shrimp sizes.

Pond and Water Management
Most respondents reported that ponds are prepared by drying. Sediments are raked over mechanically and ponds are left resting until the following culture cycle. Agricultural lime is applied to all ponds. Salinity for shrimp culture in the region averages 35 ‰. The main water source is the Sea of Cortés because freshwater reservoirs are very limited in the area. During a culture cycle, salinity in ponds rises rapidly due to water loss by evaporation. Some farms have reported 50 ‰ during the peak of the dry season. When water exchange is performed, farmers use seawater (usually once a week). Before entering the ponds, seawater is filtered with 400-500 μ meshes.

Problems Encountered and other Information
Farmers did not provide information on shrimp selling price. Fish used in polyculture were obtained from the inlet channel; therefore, prices were not available. Other reserved information included farm budget, feed and labor prices.

Angostura
This municipality is located in the central-north of Sinaloa. A total of 2 farms were visited and the owners interviewed. They both were males.

Farm profile
The average area per farm is 188 ha. The smallest one has 76 ha, while the largest covers 300 ha. These farms have been operating between 4 and 10 years and the average depth of the ponds is 1.5 m.

Stocking Practices
Stocking density for shrimp averaged 10 pcs/m^2 ranging from 7 to 12 pcs/m^2. The cost of shrimp postlarvae varied from 6 to 7 USD per thousand. When available, snapper fry (*Lutjanus spp*) are stocked in ponds at one farm. Density used and cost of snappers was unknown, since fish are caught from the inlet channel and introduced to the shrimp ponds. Shrimp seeds were always purchased directly from hatcheries. These farms generally culture shrimp during one cycle per year only.

Pond and Water Management
All respondents prepare their ponds by drying. Sediments are raked over mechanically. Agricultural lime is applied to all ponds and fertilizers are rarely used since all farms use commercial feeds. Ponds are slowly refilled with filtered seawater.

Water exchange was practiced once a week during high tide. When it was necessary to discharge water, water was discharged to the drainage canals connected to the ocean. Both farms monitor salinity but none of the respondents were doing a complete monitoring of water quality.

Parasites and Disease Problems
In general, the respondents did not experience severe disease problems. However, some disease problems that were encountered included white spot disease, Taura syndrome, fungal infection and bacterial disease. All diseases were reported with the same incidence (50%). According to the owners the white spot disease and Taura syndrome are frequent in their farms. The use of lime and sun drying to eradicate parasites is a common practice.

Harvesting and Yield
Culture period was 120 days for the shrimps and snappers.

Table 2. Percent distribution of respondents according to sex and civil status.

Characteristics	**Municipalities**							
	Angostura %	*Culiacán* %	*Escuinapa* %	*Guasave* %	*Los Muchis* %	*Mazatlán* %	*Rosario* %	*Overall* %
SEX								
Male	100	100	100	90.5	100	100	100	96.83
Female	0	0	0	9.5	0	0	0	3.17
CIVIL STATUS								
Single	0	0	0	0	0	0	0	0
Married	100	100	100	100	100	100	100	100

Total draining is the only method used for harvesting both shrimps and snappers.

Average weight of shrimp at harvest was 19-22 g or about 50 pcs kg^{-1}. Shrimp yield was 500 to 600 kg ha^{-1}.

Problems Encountered and other Information
A decrease of productivity was reported in one of the farms, apparently diseases are the cause of this problem. The respondents identified loss of product due to stealing as a problem that occurs. The two farmers consider tilapia-shrimp polyculture as a good culture alternative.

Culiacán
This municipality is located in the central region of Sinaloa. A total of 9 farms were visited, although data were collected from 6 farms only. In 83% of the farms, respondents were legal representatives of the owners and 17% were managers. All respondents were men.

Farm profile
The average farm area in Culiacán was 307 ha with all of this area devoted to shrimp culture, ranging from 45 to 1,000 ha. Sixty-six percent of the farms had been operating for 10 years, while the other 34% had operated between 6 and 8 years. The average depth of pond was 1.5 m. Seawater is the only source of water for all farms.

Stocking Practices
Stocking densities in this area is highly variable, in 50% of the cases stocking densities was 5 pcs/m^2. One farm (17%) reported the highest density of 20 pcs/m^2. The cost of shrimp postlarvae was 6 USD per thousand. Sixty percent of the farms purchase the postlarvae from a single laboratory named "Cultivos Morales", while the other 40% obtain their seeds from laboratories that differ year to year.

Sixty-six percent of the farms practice a single cycle per year. One farm runs two cycles and one farm reported that occasionally runs three cycles a year.

Pond and Water Management
All respondents prepare their ponds by drying. Sediments are raked over mechanically. Agricultural lime is applied to ponds in the majority of the farms (83%) as prophylactic measure. One farm reported the use of ammonium as disinfectant. Fertilizers are not used since all farms use commercial feeds.

Ponds are slowly refilled with filtered seawater. Water exchange is conducted once a week during high tide. When it was necessary to discharge water, water was discharged to the drainage canals connected to the ocean. All farms monitor salinity but none of the respondents were doing a complete monitoring of water quality.

Parasites and Disease Problems
The most common diseases reported were white spot disease, Taura syndrome and bacterial diseases (50%). Fungal infections and parasites were reported with lower incidence (33%).

Harvesting and Yield
The majority of the farms (80%) reported culture periods of 120 days. One farmer reported cycles of 150 days. Shrimp yield averaged 880 kg ha^{-1} and varied from 200 to 1,860 kg ha^{-1} per year. Average weight of shrimp at harvest was 19.3 g or about 51 pcs kg^{-1}, varying between 12 and 24 g.

Problems Encountered and other Information
All farms reported production losses probably related to diseases. Stealing was reported in 33% of the farms. One farm reported heavy metal pollution and one farm alleged production losses due to red tides.

Escuinapa
The municipality of Escuinapa is located in South Sinaloa. A total of 4 farms were visited, but only 2 were active. The respondents in both cases were managers.

Farm profile
The average farm area in Escuinapa was 68.25 ha, the smallest extension is 36.5 ha and the maximum was 100 ha. The time they have been in operation is 5 and 8 years respectively. The average depth of pond was 1.5 m.

Stocking Practices
Average stocking density in the region was 13.5 pcs/m^2 ranging from 12 to 15 pcs/m^2. In all cases the cost of shrimp postlarvae was 8 USD per thousand postlarvae. Larvae are purchased from different laboratories. Both farms conduct two culture cycles per year.

Pond and Water Management
The two respondents reported that pond preparation is conducted by sundrying. Sediments are raked over mechanically. Commercial bleach was reported for disinfection and one farm reported the use of formalin. After disinfecting treatment,

Table 3. Tenure status and years engaged in shrimp farming.

Characteristics	Municipalities							
	Angostura %	*Culiacán* %	*Escuinapa* %	*Guasave* %	*Los Muchis* %	*Mazatlán* %	*Rosario* %	*Overall* %
TENURE STATUS								
Owner	100	0	0	43	50	66.7	16.7	36.5
Manager	0	17	100	19	0	33.3	66.6	19.2
Legal Representative	0	83	0	48	50	0	16.7	44.3
YEARS ENGAGED IN SHRIMP FARMING								
< 5	50	0	50	4.8	0	33.3	0	5.7
5 – 10	50	100	50	81.0	60	66.7	83.3	77.0
11 – 15	0	0	0	14.2	30	0	16.7	15.4
> 15	0	0	0	0	10	0	0	1.9

ponds are sprayed with agricultural lime. Ponds are filled slowly with seawater.

Parasites and Disease Problems
The most common problem reported is white spot disease (100%). However occasional breakouts of bacterial diseases and fungal infections occur.

Harvesting and Yield
One farm reported culture period for shrimps of 120 days while the other reported 150 days. Average weight of shrimp at harvest was 14 g or about 154 pcs kg^{-1}. Shrimp yield ranged between 1,000 and 2,250 kg ha^{-1}.

Problems Encountered and other Information
No other problems were reported in this region.

Guasave
Guasave is located in the Nort-Central coastal region of Sinaloa. Twenty-two farms were visited and information was gathered from 21 (95%) of them with one farm inactive. Respondents were in 43% of the cases the farm owners, 38% were legal representatives and 19% were farm managers. The majority of the respondents were males (90.5%) while 9.5% were females.

Farm profile
Total farm size averaged 56 ha, ranging from 9 to 140 ha. Farms have been in operation for an average of 8 years. The youngest farm has been in operation for 4 years and the oldest for 12 years. Pond depth was maintained at 1.5 meters.

Stocking Practices
Most farms in the region cultivate shrimp primarily (81%); however, in four farms (19%) polyculture is practiced. Three farms stock tilapia (*Oreochromis spp*) and one cultures common snook (*Centropomus spp*). All farms have only one culture cycle per year. Shrimp stocking rate ranged from 7 to 25 pcs/m^2, but the most common stocking rate varies between 10 and 12 pcs/m^2 (71% of the farms).

Shrimp postlarvae were obtained from different laboratories of the State. Shrimp postlarvae are purchased at 6-7 USD per thousand. Culture period was for 3 months.

Pond and Water Management
Pond management consists primarily of pond drying and mechanical raking over of sediments using tractors. In 26% of the farms, bleach and Iodine are used as disinfectants; however, in some occasions other chemicals (not specified) are used for bacterial eradication. In 39% of the farms inorganic fertilizers are used (urea and phosphates). After dry out and disinfection, ponds are treated with agricultural lime. Ponds are slowly refilled with seawater.

Parasites and Disease Problems
The most common disease problem is the presence of the white spot disease (85.7%), and the Taura syndrome (66.7%). Infections caused by bacteria are reported in 52.4% of the farms. Other problems reported were presence of parasites (23.8%), mortalities attributed to red tides (19%) and vibriosis (9.5%).

Harvesting and Yield
The majority of the farms reported a culture cycle of 120 days (69%) and 31% reported 150-days cycles. Shrimp yield was 140 to 1,660 kg ha^{-1} per year. Average weight of shrimp at harvest averaged 35 g, varying between 7 and 35 g.

Problems Encountered and other Information
In 85% of the farms production losses have been reported. Part of this loss is attributed to diseases and all the farmers that reported this condition agree on using tilapia as an alternative to improve production. Robbery was reported in 47% of the farms, while 9.5% of the farmers attributed losses to contamination due to pesticides (9.5%) or hydrocarbons (4.8%). These farmers considered tilapias as an alternative to improve production.

Los Mochis
Los Mochis is located in the Northern part of the State. Seventeen farms were visited and information was obtained from ten (58%) of them. In 50% of the cases respondents were owners and the other 50% were legal representatives. All respondents were males.

Farm profile
Mean total farm size in Los Mochis was 144.9 ha. The smallest farm had a total area of 17 ha, while the largest one had 300 ha. The average operation time is 10.5 years, ranging from 5 to 20 years.

Stocking Practices
All farms cultured shrimp exclusively at stocking rates ranging between 10 to 35 pcs/m^2 (mean of 18.1 pcs/m^2). The cost of shrimp postlarvae varied widely depending from farm to farm (6 to 10 USD/thousand larvae). Postlarvae are purchased from different laboratories located in the State. Fifty percent of the farms practice one cycle per year, while the other 50% reported two cycles.

Pond and Water Management
Pond management consists primarily of pond drying and mechanical raking of sediments. Farms occasionally use chemicals (not specified) for bacterial eradication. After drying, ponds are treated with agricultural lime. Ponds are slowly refilled with filtered seawater.

Parasites and Disease Problems
The most common disease problem is the presence of the white spot virus (60%). Infections caused by bacteria are also reported in 60% of the farms. Other problems reported were presence the Taura syndrome (30%), funguses (20%), and vibriosis (10%).

Harvesting and Yield
Fifty percent of the farmers reported a culture cycle of 120 days and the other 50% reported 150-days cycles. Shrimp yield was 760 to 3,710 kg ha^{-1} per year. Average weight of shrimp at harvest averaged 19.6 g, ranging between 15 and 25 g.

Problems Encountered and other Information
In 80% of the farms production losses have been reported. Part of this loss is attributed to diseases. Sixty percent of the farmers that reported this condition consider using tilapia as an alternative to improve production. Robbery was reported in 70% of the farms.

Mazatlán
This municipality is located in the south of Sinaloa. Information was obtained from three farms. In two farms, respondents were owners and in one the respondent was the manager. In all cases respondents were males.

Farm profile
Total farm size averaged 110 ha, ranging from 40 to 250 ha. Farms have been in operation for an average of 5.6 years. The youngest farm has been in operation for 4 years and the oldest for 8 years. Average pond depth was slightly lower than the rest of the farms in the State with 1.3 meters.

Stocking Practices
All surveyed farms culture only shrimps and reported two cycles per year. Stocking densities in this area varied from 12 to 16 pcs/m^2. The cost of shrimp postlarvae ranges between 6 and 10 USD per thousand. Postalarvae are purchased from different laboratories.

Pond and Water Management
Pond management is similar to the other regions and consists primarily of pond drying and mechanical removal of sediments. After drying, ponds are treated with agricultural lime. Ponds are slowly refilled with filtered seawater.

Parasites and Disease Problems
The presence of the white spot virus and vibriosis were reported in 67% of the farms. Infections caused by bacteria, funguses and the Taura syndrome were reported in at least one farm (33%).

Harvesting and Yield
Shrimp yield ranges from 1,000 to 2,400 kg ha^{-1} per year. the duration of culture cycles is 120 days and the harvested shrimp weight varies from 12 to 15 g, with an average weight of 14 g.

Problems Encountered and other Information
Two farms reported production losses and the farmers consider the use of tilapia as an alternative to improve production. Robbery was reported in one farm (33%).

Rosario
Rosario is located in the southern coast of Sinaloa. Six farms were visited and information was obtained from all of them. The respondent from one farm was the owner, legal representatives answer in four farms and one respondent was the manager. In all cases respondents were males.

Farm profile
Total farm size averaged 128 ha, ranging from 50 to 180 ha. Farms have been in operation for an average of 9 years, ranging from 5 to 15 years. Average pond depth was 1.5 meters.

Stocking Practices
The majority of the farms reported two cycles per year (84%) and one reported one cycle. Stocking densities in this area varied considerably, ranging from 7 to 25 pcs/m^2. In one farm, tilapia culture was reported as an alternative practice. The cost of shrimp postlarvae ranges between 6 and 8 USD per thousand; however 84% of the farms pay 6 USD per thousand postlarvae. Post-larvae are purchased from different laboratories.

Pond and Management
In all cases pond management consists on pond drying and mechanical removal of sediments. In all farms, bleach is used as disinfectant; however, one farm reported the additional use of Iodine. After drying and disinfection, ponds are treated with agricultural lime. Ponds are slowly refilled with seawater. One farmer reported the use of probiotics to improve shrimp health and production.

Parasites and Disease Problems
The only reported disease problems were the white spot disease and the Taura syndrome (50%).

Harvesting and Yield
The duration the culture cycle varies from 120 days (67%) and 150 days (33%). Shrimp yield ranges from 780 to 2,500 kg ha^{-1} per year, averaging 1,500 kg ha^{-1} per year. Average weight of shrimp at harvest averaged 17 g, varying between 13 and 20 g; however most farmers (84%) reported a harvesting weight between 15 and 20 g.

Problems Encountered and other Information
Sixty seven percent of the farms reported production losses and 33% of them consider that tilapia culture can be a good alternative. Robbery was reported in 33% of the farms.

CONCLUSIONS

Shrimp farms in Mexico have been severely impacted by disease and to a lesser level by theft. Many farmers have considered tilapia polyculture with shrimp as an alternative production scheme. However, there is a lack of saline tolerant tilapia available. Because many of the farms are using a low or zero effluent plan, the salinity in the production ponds increases to hyper-saline levels, above 35 ppt. Few, if any, of the *O. niloticus* or *O. aureus* strains will grow or even survive these conditions. Only a few of the red skin hybrid tilapia will thrive under these salinity levels. The farms that have attempted polyculture have simply thrown a few locally available tilapia into the ponds with no real plan or data collection. They did not have any results to report.

Reports of tilapia-shrimp polycultures in Honduras proved to be premature. On further investigation we were unable to find any actual instances where farms had implemented any commercial applications or even experiments. Apparently, all farmers are waiting for published reports and recommendations before they attempt such a change in their culture systems.

It appears that replicated trials are needed to determine if a polyculture of tilapia and shrimp can be practical under the conditions found in western Mexico. Properly selected, saline tolerant, tilapia should be stocked in one or more treatments, along with controls, to determine practicality.

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Cite as: [Author(s), 2004. Title.] In: R. Harris, I. Courter, and H. Egna (Editors), Twenty-First Annual Technical Report. Aquaculture CRSP, Oregon State University, Corvallis, Oregon, [pp. ___.]