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A SUSTAINABLE SHRIMP MARICULTURE INDUSTRY FOR ECUADOR

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Characteristics of the Mariculture Industry

Present Status and Future Options for Improving the Efficiency of Shrimp Mariculture

Estado Actual y Opciones Futuras para Mejorar la Eficiencia de la Maricultura del Camarón

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Resumen

En 1986 había más de 94.000 ha autorizadas para construcción de piscinas camaroneras, estaban terminadas unas 60.000 ha y de éstas sólo un 50% estaban en producción de postlarvas (pls).

La mayoría de los cultivadores siguen un método de manejo semi-extensivo, con densidades de siembra de 10.000 a 50.000 pls/ha. Se usa el flujo de mareas o el bombeo diario para el intercambio de agua en las piscinas. Los nutrientes son proporcionados por la producción natural del fitoplancton en los estanques. Las empresas con más alto grado de infraestructura y recursos económicos usan el método semi-intensivo con densidades de siembra de 100.000 a 180.000 pls/ha. En general, densidades de siembra mayores que 50.000 juveniles requieren de fertilización o la dispersión de las pls en muchas piscinas para aprovechar la ventaja de la productividad el fitoplancton. Los estanques para "semillero" usados en las operaciones simi-intensivas son sembrados con más de 2 millones de pls por hectárea. De aquí son trasladados a las piscinas de crecimiento después que alcancen pesos de 0,5 a 1,0 gr.

Aproximadamente del 50 al 60% de pls "sembradas" en las piscinas del Ecuador son obtenidas en el ambiente natural. El 50% de pls corresponden a P. vannamei, selección que está basada en su capacidad para resistir y crecer en el ambiente riguroso de las piscinas, antes que en la disponibilidad de pls. Cuando las pls están mezcladas con detritus y el tiempo de transporte es largo, la mortalidad de pls puede llegar a un 50%. En general las pls capturadas se venden aun intemediario que las transfiere a centros de acopio para la limpieza, luego son empacadas y transportadas hasta los criaderos, usando para esto aire y oxígeno comprimidos. La temperatura no se controla en el tanque de transporte. La aclimatación de las pls se realiza en piscinas de crecimiento, siendo esta operación materia de controversias considerables.

Los autores analizan en detalle varios aspectos de los sistemas de manejo en los estanques "semilleros" y de las piscinas de producción, incluyendo el uso de alimentos concentrados granulados (pellets).

La vigilancia de los parámetros ambientales (oxígeno disuelto, pH, temperatura, salinidad, turbiedad), es efectuada en las piscinas con cultivos semi-intensivos con fines de manejo. Así, valores de oxígeno menores que 3 ppn origina la suspensión de alimentos y aumento del ingreso de agua por bombeo; temperaturas menores que 24°C es la referencia para aumentar la profundidad del agua en las piscinas; si la turbiedad es menor que 32 cm o hay pH alto, se suspende la fetilización.

Se acepta ampliamente en Ecuador que la conversión de áreas de manglar a pisicinas camaroneras es una de las razones principales de la declinación de la abundancia de pls. También, los autores mencionan que lugares para piscinas en algunas áreas de El Oro compiten con tierras agrícolas y de patoreo.

Entre las recomendaciones planteadas por los autores se encuentran: (a) capacitar técnicos, habiéndose estimado que el Ecuador necesitará entre 700 y 800 técnicos para laboratorios y para las piscinas ya autorizadas; (b) un programa de capacitación para personal de los centros de colección y para los que transportan las pls; (c) proporcionar facilidades de mantenimiento para desarrollo de pls; (d) establecer un laboratorio de diagnóstico para aplicación de niveles adecuados de alimentación; (e) mejorar los conocimientos de los productores; (f) difusión de métodos apropiados para aclimatación de pls y estanques "semilleros"; (g) desarrollo de raciones ecuatorianas para maduración en los laboratorios.

Historical Development of Shrimp Mariculture in Ecuador

The Incas may have been the first to farm shrimp in Ecuador some 400 years ago by impounding waters containing penaeid shrimp larvae. Modern shrimp mariculture began in the late 1960s in El Oro province in southern Ecuador when an owner of a banana plantation noticed that flood waters impounded behind a dike yielded a bountiful harvest of shrimp. By 1977 there were some 360 hectares (ha) of shrimp ponds in production (R. Naboa, personal communication). In the early days of the industry, investors were able to pay off the costs of pond construction within two or three years. This, combined with seemingly abundant postlarvae and the relatively high price for shrimp in the U.S. market, led to the rapid development of the shrimp mariculture industry. By 1983 the shrimp industry had expanded to an estimated 89,367 ha of (Alvarez, this volume) and production peaked in 1982-83 at 23,300 metric tons (m.t.) of shrimp reportedly worth U.S.$218.7 million (National Marine Fisheries Service, 1986).

There is a feeling among producers interviewed by the authors that the shrimp industry is currently undergoing a consolidation. The rapid expansion experienced in the early 1980s is over. Future development, the producers say, will not be in the area of new pond construction but in the acquisition of concessions not presently in use and the development of hatcheries.

The so-called integrated enterprise has recently become the predominant "survival unit" in the Ecuadorian shrimp industry. It incorporates shrimp ponds with packing and export operations, and may have a hatchery in operation or under construction. Such an integrated enterprise may include several of the following segments:

- import house(s) in the United States and other markets
- packing plant
- growout ponds (this may include several companies)
- feed and/or fertilizer plant
- fishing fleet (sourcing)
- larval collection and air and/or ground transport group(s)
- hatchery

Area in Production

In 1986 there were more than 94,000 ha of shrimp ponds authorized for construction and approximately 60,000 ha had been completed (Table 1). Based on a preliminary aerial survey and interviews with shrimp producers in the Guayas-El Oro production areas, the authors estimate that only half of the completed ponds were in production in June-July 1986, presumably because of postlarvae shortages.

Pond Management Techniques

The national crisis brought about by the depletion of wild stock postlarvae (PL), during 1984-85, has divided Ecuadorian farm management strategies into two distinct camps with contrasting culture and management strategies.

Semi-Extensive

Most farmers pursue a semi-extensive management strategy which calls for stocking densities of 10,000 to 50,000 PL per hectare. These farmers accept lower production returns along with substantial reductions in their production costs. Producers using semi-extensive systems may use the tides and/or daily pumping to provide water exchange in gravity drained flow-through ponds. Nutrients are provided by natural phytoplankton production in the ponds.

Semi-Intensive

Companies with a higher degree of infrastructure and economic resources maximize their production by utilizing a semi-intensive method. Here, higher stocking densities of 100,000 to 180,000 PL per hectare are maintained, with correspondingly higher fixed costs. The majority of these companies aggressively pursue wild stock postlarvae by paying more for catches, or are meeting their stocking demands with their own hatchery production. Nursery ponds utilized in semi-intensive operations are stocked with up to 2 million PL per hectare. The juveniles are moved from nursery ponds to growout ponds after reaching weights of 0.5 to 1.0 grams. Stocking densities at levels higher than 50,000 juvenile shrimp require fertilized growout ponds, or postlarvae spread over many ponds to take advantage of phytoplankton productivity and reduce risks of loss from overstocking. Stocking density is often a function of wild stock postlarvae availability.

Generally, the small farmers or farmers who do not have a highly developed infrastructure do not share the technological advancement employed by the larger companies. This lack of technology among the smaller producers using semi-extensive methods has resulted in high mortality at high stocking densities. On the other hand, farmers who have higher fixed costs and infrastructure development, have also aggressively pursued the advancement of their technology which is reflected in an increase in overall production levels.

Demand for Postlarvae

Pond operators obtain postlarvae by one or more of several methods, including:

- purchase from middle men
- collecting PL with personnel from the shrimp farm in estuaries close to the farm
- collecting from artificial estuaries (semilleros) constructed in mangrove areas bordering the shrimp farm
- collecting in the intake canals
- collecting from nursery ponds, when they are tidally filled during the monthly flood tide aguaje)
- purchases from a hatchery
- imports from other countries

Approximately 50 percent to 60 percent of the postlarvae stocked in Ecuadorian ponds are wild-caught and purchased from middle men. Postlarvae prices are based on availability, principally of Penaeus vannamei. These animals typically change hands two to three times between the fishermen and the growers' ponds. A fisherman receives approximately 100 sucres per 1,000 postlarvae from middlemen. The postlarvae are then sold to the pond owners or to other middlemen for approximately 450 to 1,000 sucres per 1,000.

Wild-caught Penaeus vannamei are generally more abundant during the months of December through March. During these months well above 50 percent of the catch is P. vannamei with a notable decrease in the presence of P. occidentalis. The selection of P. vannamei as the species of choice was not based on its availability (Klima, 1986 and Zimmerman et al., 1986) but on its ability to resist and grow in a very rigorous pond environment (Snedaker et al., 1986).

During the 1985-86 stocking season the supply of postlarvae remained high through the middle of March 1986 (Table 2). Producers who had ample funds were able to rapidly stock their ponds. Many of the larger pond owners have resorted to hiring groups of fishermen and a middleman to transport the postlarvae and pay them a salary nearly double what they would otherwise earn. A fisherman can thus earn between 2,000 and 5,000 sucres in a day, which may account for a significant percentage of overall annual earnings for these artisanal fishermen. Since the capture of postlarvae is determined by moon phase, tide, water temperature, location and the fisherman's skill, he may be limited to five to eight days of good fishing per month. A middleman can sell between 500,000 to 1 million PL per day, but this activity is limited by the length of time that PL are available and his capital expenditures, which include equipment and short-term operating loans at interest rates of 25 percent to 50 percent per two month period.

Postlarvae can represent 40 percent to 60 percent of the overall operating costs in a farm operation. Several producers have resorted to importing postlarvae from the United States and other countries, though there have been problems with poor quality and size consistency. A comparison of the effect of wild and imported seed stock on production cost estimates is given in Table 3.

There are no data on the numbers or species composition of the postlarvae caught by the artisanal fishery, but the Camara de Productores de Camarones del Guayas estimates that the fishery had provided 3 to 4 billion P. vannamei PL each year until the 1983-84 El Nino. There is an unmistakable trend following the El Nino toward short spawning seasons and subsequent lack of wild seed stock. Table 4 provides estimates for the number of PL utilized by the industry in recent years and the potential PL demand.

Postlarval Transport and Survival

When wild-caught postlarvae are mixed with detritus, and the length of time from capture point to transport tank is prolonged, PL mortalities can be as high as 50 percent. The catch is then sold to middlemen who transfer the postlarvae to collection centers for further cleaning. When sufficient numbers have been accumulated, the postlarvae are repacked and transported to nursery ponds. Compressed air and oxygen are used to maintain postlarvae during transport, with battery (12v) operated air compressors and air stoves. The water temperature in the transport tanks is not controlled, nor are chemicals added which would inhibit the effect of disease or chelate toxicants. In the past, the number of larvae being purchased was estimated by eye. Although this technique seemed adequate during times when wild-stock postlarvae were abundant and prices were relatively low, economic competition eventually forced farmers to mathematically quantify their postlarvae. Volumetric counting techniques rapidly became standard operating procedure, although they had inherent counting errors of up to approximately 30 percent depending on container design, water volume, larvae density, and mixing techniques. As a result, some of the more technically advanced producers now use a reduction counting technique with standardized water temperatures and mechanical mixing apparatuses. This technique has successfully lowered the margin of error to acceptable levels of approximately 10 percent. The improvement of the level of confidence in the quantification of postlarvae stocked into ponds has resulted in the development of a valuable tool for water management decisions, feed conversions, harvest projections and fertilization programs.

Acclimation of Postlarvae

Postlarval acclimation to growing ponds is a subject of considerable controversy. Many producers favor limited acclimation procedures. A technically advanced farm, Empacadora Nacional, uses a slow acclimation program combined with controlled ecological conditions in the acclimation station. This program uses a continuous flow-through system while feeding Artemia salina, nauplii and steamed egg yolk. Acclimation densities of up to 500 five-day-old postlarvae per liter, a rate of two parts per thousand salinity change per hour, and a 1 degree Celsius change in temperature have yielded a 1 percent mortality over a 12-hour acclimation period, a significant improvement over the previous rudimentary techniques. The lengthier process also allows farm biologists to evaluate the condition and behavior of the postlarvae.

Nursery Pond Management Systems

Stocking a nursery pond is not generally a problem, providing the postlarvae do not come long distances or from environmental conditions which vary greatly from pond conditions. Survival estimates are made from samples of 100 animals, which in some cases are held in fine-meshed nets in the nursery ponds for 48 to 96 hours.

Among the more technically advanced companies, which generally employ semi-intensive management techniques, much attention is paid to the preparation of nursery pond bottoms to produce nutrient-rich water, since it is believed that feeding reduces mortality during the critical first three weeks. Producers prepare both growout pond and nursery pond bottoms by allowing them to completely sun dry and oxidize. Humid areas are hand-tilled and oxidized with a saturated solution of hypochloride. Water is allowed to half fill the nursery after passing through a 1 mm filter screen. Inflows and effluent weirs are then sealed for five days. Fertilizer at a concentration of 1.3 parts per million (ppm) of nitrogen and 0.3 ppm of phosphorus is applied in a single dose. Algae are allowed to grow for two to five days before the nursery ponds are completely filled. Water is commonly transparent to a depth of 30 centimeters at this point. Feed for juvenile shrimp with 35 percent protein is added 24 hours prior to stocking at a rate of 100 pounds (45 kg) per hectare. The nursery ponds are then stocked at densities of up to 2 million postlarvae per hectare. The shrimp are harvested by draining the pond 50 days after stocking when their average weight is 1.5 grams. Survival rates as high as 65 percent are commonly recorded using these techniques.

Production Pond Management

Stocking

Growout ponds can be stocked in two ways. First, postlarvae can be placed directly in 5 to 15 hectare units for a 180 to 210 day growout period, bypassing the need for nursery ponds. With the second method, larger juvenile shrimp harvested from nursery ponds, as described above, are placed in the growout ponds.

Stocking densities in growout ponds farmed by semi-intensive methods range from 50,000 to 180,000 hatchery-reared postlarvae per hectare. Feed and fertilization are carefully controlled and ponds are treated as production units. Yields range from 1,400 to 1,300 kg per hectare per year of whole shrimp.

Semi-intensive management systems utilized by integrated enterprises, generally employ trained biologists who rely upon a wide range of physical and chemical information when making management decisions. Ecological parameters are monitored in all ponds.

According to Empacadora Nacional C.A. (a major feed producer), stocking PL directly in growout ponds at densities of 160,000 PL per hectare may yield 45 percent survival after a 180-day growout period. Stocking with juveniles at densities of 80,000 per hectare yields 75 percent survival at the 22 gram size, the target harvest weight, obtained in approximately 140 days.

Shrimp harvests as high as 3,500 pounds per hectare per turnover with two turnovers per year are common in semi-intensive operations. However, semi-extensive producers often realize a greater margin of profit with lower stocking densities, lower levels of technology and a reduced management effort.

Feeding

In semi-intensive operations, the use of compounded dry pelleted feeds is widely accepted. Daily applications are made from canoes in a zig-zag fashion over the entire pond surface. There are two basic feed formulations currently in use. One consists of 35 percent protein and 8 percent fat, and is used to feed juveniles until they obtain an average size of 6 grams. Once the juveniles reach 6 grams, the feed ration changes to a growout production formula containing 25 percent protein and 5 percent fat. Feed ration levels are adjusted weekly according to the shrimp weight. Stringent quality control guidelines are followed in the feed manufacturing process. Local producers strive to maintain the stability of the pellet in the water for more than four hours and maintain digestibility greater than 70 percent. The use of shrimp heads and other by-products in shrimp feeds are being considered.

Several producers utilizing semi-intensive management strategies have recently recognized disease-related production problems. Use of medicated feeds (Table 5) could have a significant impact on production capacities, provided the following factors are taken into consideration:

- identification of benefits from point specific versus broad spectrum prophylactic antibiotic applications
- economic feasibility at the commercial level
- the evaluation of potential environmental and health impacts

Costs and Profits

Many producers using semi-extensive management strategies fertilize only during the dry season when the water pumped from the estuary is less productive. While these producers have used locally produced shrimp feeds, they often view the use of feed with great distrust. The feed, in their opinion, breaks down in the water, making it little more than an expensive fertilizer that does not produce sufficient improvement either in quantity or size of shrimp to offset the additional capital outlay.

Excluding the cost of financing the shrimp farm operation during the growth period, it costs from U.S. $.70 to as much as $1.20 to produce a pound of shrimp using the semi-extensive approach (harvest rate of 15,000/ha/2.2 harvests/yr), and approximately U.S. $.40 more per pound to use feeds. Producers receive between U.S. $2.20 to $3.50 per pound of shrimp depending on the size of the shrimp and time of year.

Although there would appear to be a greater net profit to the semi-extensive producer if higher stocking densities were used, neither the quality of the feed nor the technology currently available seem adequate to prompt changing their methods. However, some producers are open to alternative farming strategies providing sufficient quantities of PL are available for higher density stocking, high quality feed is available and adequately trained biologists are available to operate the shrimp farms.

Ecological Monitoring

Monitoring of dissolved oxygen, pH, water temperature, salinity and water turbidity is carried out twice daily in many semi-intensive operations; commonly at 6 a.m. and again at 2 p.m. Although a routine fertilization program is utilized, results from water quality analysis override the routine schedule of fertilization.

Dissolved oxygen and water temperatures are priority parameters and used as warnings in basic biological management decisions. A low dissolved oxygen reading of less than 3 ppm dictates the suspension of feeding and an increase in the flow of incoming water. A low water temperature of less than 24oC is the basis to increase water depth in a pond, in an attempt to cushion or reduce the rate of change in water temperature in the deeper areas by decreasing pond surface area in relation to total volume. In the afternoon, high dissolved oxygen and/or high water temperatures dictate similar reactions. Afternoon monitoring is also used as a guideline for fertilization. Water turbidity readings of less than 32 cm and/or high pHs also call for the suspension of routine fertilization. Hydrogen sulfides, ammonia and phosphate concentrations are analyzed weekly in all ponds.

Water Quality Management

Each pond in the semi-intensive management system, whether a nursery or production pond, is managed for its percentage of water volume exchange. Water level readings over the effluent weir boards are measured every 2 hours for 12 hours. The diurnal tide reflects two shifts in pumping capacity so that water level values can be extrapolated over a 24-hour period to calculate inflow volume. Once the pond system is calibrated, adjustments are made daily, based on ecological parameters, stocking densities and shrimp weight. Generally, production ponds are initiated with a 6 percent daily exchange rate, while final water exchange rates may gradually increase over time to 17 percent per day. Some of the more advanced producers, using extensive management practices also pump daily at rates ranging from 5 percent to 10 percent of the pond volume.

Production Capabilities

With stocking densities of 15,000 to 30,000 PL per hectare and 1.5 to 2.2 harvests per year, many farmers estimate harvest levels at 800 to 2,100 pounds/hectare/year.

Should producers change their production strategy to one which incorporates low stocking densities with fewer turnovers (harvests) per year, then they would be able to produce larger-sized animals and potentially more valuable crops. For example, one company (Langacua, S.A.) using an extensive management strategy stocks 18,000 to 25,000 juveniles per hectare. These animals grow to 24 gm size (26-30 count) in 100-120 days in the rainy season and 120-140 days in the dry season, with an overall survival rate of 90 percent, yielding approximately 600 pounds of shrimp 2.5 times per year. This extensive strategy produces on the average 2,100 pounds per hectare per year. Such an approach seems to offset potential losses due to inadequate supply of postlarvae and may have the potential of stabilizing overall production, making levels of production achieved in previous years obtainable at lower costs, with fewer postlarvae and/or producers.

Pond Siting, Construction and Utilization

It is widely believed in Ecuador that the conversion of mangrove areas to shrimp ponds is a major reason for the decline of PL abundance. Alvarez (this volume) provides estimates for the changes in area of mangroves, salinas and shrimp ponds between 1969 and 1984. Based on remote sensing data, he estimated that the total mangrove area in Ecuador has decreased by 10.6 percent during this period.

CLIRSEN, as reported by Valdiviezo (1985) utilizing information obtained from the 1982-83 remote sensing studies, tabulated mangroves, shrimp ponds and salt flats in El Oro and Guayas Provinces (Table 6). The location and distribution of mangrove in El Oro, is distinct from other provinces, and may be described as a narrow belt less than 100 meters wide running along the periphery of the estuary. Shrimp ponds, agriculture and pasture lands lie inland from this narrow mangrove belt. In many areas shrimp ponds were built leaving no mangrove buffer. Sites for shrimp ponds in several areas in El Oro also compete directly with agricultural and pasture lands.

Mangroves in the Guayas Province are concentrated on islands and as belts of varying widths along the continent. Shrimp ponds in the area appear to have first been built in salina (salt flat) areas and later expanded into surrounding mangroves.

If one were to prioritize the damage to the mangrove resources along the Ecuadorian coast, the most impacted area would be El Oro, followed perhaps by Manabi. In the Guayas, although impacted by the shrimp farm development, a considerable mangrove area still exists. The potential threats to mangroves in the Guayas and to the shrimp industry may lie in a combination of increased siltation, reduced water circulation, and upstream changes in water quality due to a reduction of fresh water inputs and increase in chemical intensive agricultural practices. For a more detailed discussion see Twilley (this volume).

Coastal areas in Esmeraldas, containing less than 2,000 ha of shrimp ponds, have been little affected by the industry. Considering the copious amount of rainfall in this province (Twilley, this volume), the impact on mangrove areas from shrimp farm development may be limited to a maximum of 5,000 hectares, which is a maximum of one quarter of the apparent mangrove area in 1983.

Investment Requirements

During 1984 investments to develop a shrimp farm ranged from 40,000 to 600,000 sucres per hectare (Table 7). If the only access to the farm was by boat, an additional investment would be required.

Beyond the initial acquisition and construction costs associated with the development of a shrimp farm, large pumps and piping as well as water quality equipment are basic requirements. Much of this equipment must be imported. For discussions of the problems associated with imports see Perez and Robadue (this volume).

Recommendations

Many actions should be taken at all levels to help the shrimp industry reach a stable level of development. Here a few measures related to shrimp pond improvements are discussed:

1. The single most effective way to stabilize this industry is to close the gap between the legal and apparent (s/165:1 U.S.D.) exchange rates. In the early months of 1985, exporters received 108.50 sucres per dollar exported, in addition to a 15 percent Abono Tributario for the total dollar value exported, which is calculated at s/95:1 U.S.D. The abono is like a bond with a one year maturity, so exporters discount it 31 percent of its value. The real benefit is calculated as follows: (95 x 0.15) - 0.31 (95 x 0.15) = s/9.83. Thus, the legal exporter of shrimp receives s/108.50 + 9.83 = s/118.33 for each dollar of export product. This step was taken in late 1986.

2. The rapid growth of the industry has made it impossible for the universities and polytechnic schools to provide enough suitably trained technicians. It is estimated that Ecuador will require an additional 700 to 800 trained hatchery technicians to fully utilize hatcheries presently under construction. With over 900 authorized shrimp farms in Ecuador, it is estimated that between 18,000 and 22,000 technicians are employed. Improvements in hatcheries and the daily operating procedures on shrimp farms through an extension program could have a direct and visible benefit for the industry and Ecuador. Such a program could be supported through a group of banks and the DIGEMA-URI Coastal Resources Management Program. It would focus on ponds which are not currently in production as well as on operations which require loans to operate or expand operations. All new loans to producers could be used to procure technical assistance from one of the approved technical assistance groups in operation today. It would be the responsibility of the extension service to examine the technical capability of consultants and technical assistant groups, and issue them a permit to work within the system. Additionally, a diagnostic laboratory with support activities in the field could be funded, bringing to Ecuador experts in areas of specific need.

Services provided by a comprehensive extension program would include:

- periodic training courses
- hatchery techniques
- water quality management
- pond production techniques
- feed development
- diagnosis of diseases
- information and data base development
- dissemination of reliable information
- postlarvae handling, transport and acclimation
- mangrove restoration
- development of an international shrimp marketing lobby

3. An immediate improvement in pond production can be achieved if producers would focus their attention on wild stock and hatchery- produced postlarval handling and acclimation methods. The efficient use of postlarvae has the greatest immediate potential gain for the producer as well as conserving this limited natural resource. Improvements in capture, transport, handling and acclimation methods for postlarvae can have an immediate and visible positive effect.

4. A training program for postlarvae collection center and transport personnel along with a certificate for course completion should be developed. Such a program would focus on improving survivability of harvested postlarvae, and conduct routine spot checks to

confirm adherence to correct procedures to help guarantee delivery of high quality wild stock postlarvae.

5. Postlarval holding facilities at farm sites to further develop postlarvae, from PL 5 to PL 21-30 should be developed. These facilities would enhance survival of hatchery-produced stock in the pond environment.

6. Steps should be taken to establish an in-country diagnostic laboratory which could monitor populations of shrimp and be responsible for the application of appropriate levels and types of medicated feeds.

7. Steps should be taken to enhance the knowledge of producers, and keep them appraised of recent advances in hands-on technology. This might be done through routine news releases.

8. Other areas that could have direct, immediate and visible positive effects on the industry include:
   - development and dissemination of improved methods for postlarval acclimation
   - stocking of nursery ponds
   - the development of acclimation, nursery and growout pond maintenance programs.

9. Pond producers should coordinate their efforts with hatchery producers to assure that their respective ponds are adequately prepared to receive postlarvae.

10. More effort should also be given within the pond producers' enterprises to control environmental parameters to prevent causes of undue stress.

11. Many improvements to feeds currently used in Ecuador can be made using locally available feed stuffs. Cost effective feeds of adequate nutritional value should be further developed using in-country feed stuffs and processing by-products for all segments of the industry (i.e. larval, maturation, nursery and growout pond diets).

12. An Ecuadorian maturation diet for use in hatcheries needs to be developed because present stocks of oysters and other shellfish in Ecuador will be gravely impacted when all the hatcheries presently under construction come on-line.

Table 1
Estimated Shrimp Pond Surface Area (in hectares)
Authorized, Completed and in Use

Province	Authorized in 1986[1]	Construction in 1984[2]	Completed and Under Construction in 1986	In Use in 1986
Guayas	72,208	52,912	------	------
El Oro	14,496	26,484	------	------
Manabi	5,407	8,377	------	------
Esmeraldas	2,241	1,595	------	------
TOTAL	94,352	89,368	60,000[3]	30-40,000[4]

1 R. Horna et al., 1986.
2 CLIRSEN, 1986.
3 R. Horna, O. Crespo, W. Bustamente, A. Lopez, 1986.
4 Aerial observation, P. Maugle, March 1986: corroborated by the Camera de Productores de Camarones del Guayas, 1986.

Table 2
1985-86 Postlarval Costs to Pond Operators*

	Sucres per thousand
May - July 1985	1,300
August - September 1985	1,800
October - November 1985	1,800
December - January 1986	1,200
February - March 1986	500

* From M. Leslie, personal communication.

Table 3
Comparison of Production Cost Estimates to a Producer Using
Wild Stock and Imported Seed Stock in an Extensive Management Method*

	Wild stock	Imported seed stock
Unit sold at U 26-30	20.00**	20.00
(PL Cost)	3.00	7.00
Gross margin	17.00	13.00

* Expenses vary significantly from one farm to another, and economics of scale are achieved above 120 to 150 hectares.

** Sales are based on an average price for U 26-30. Costs in sucres at 118 sucres per U.S. dollar.

Table 4
Two Means for Estimating Demand by Ecuador's Shrimp Mariculture Industry for Postlarvae

Estimated farm production[1] year	(m.t.)	Postlarvae required[2] (millions)	Area in cultivation[3] (ha)	Demand for postlarvae[4] (millions)
1977	3.9	420.4	360	55.4
1978	5.0	539.0	1,010	155.5
1979	6.2	668.4	3,150	485.1
1980	9.2	991.8	8,875	1,366.8
1981	11.2	1,207.4	26,360	4,059.4
1982	16.4	1,767.9	39,120	6,024.5
1983	23.3	2,511.7	51,700	7,961.8
1984	21.7	2,339.3	59,350	9,139.9
1985	18.7	2,015.9	43,150	6,645.1

[1] Source NMFS (1986) Ecuador/U.S. Shrimp Imports
[2] Based on the following calculation and assumptions (for 1977):
3.9 metric tons x 2.2 lbs/kg x 1,000,000 = lbs.
x 0.70 (tail weight) x 35 shrimp/lb)/year
x 1/0.5 (50% survival) = 4.20 x 10 8 larvae.
[3] Source: Dept. Estudios Pesqueros y Estadisticas, Sub Sec. de Pesca
[4] Estimates based on the area in cultivation used the following calculation (for 1983):
(e.g.) 51,700 ha x 35,000 pl/ha x 2.2 harvests/year
x 1/0.5 (50% survival) = 7.96 x 10 9 larvae.

Table 5
Cost Evaluation of Several Wide Spectrum Antibiotics as a Feed Additive

Antibiotic	Dosage Recommendations* (mg. per kg)	Cost** (per 50 kg bag of feed)
Nitrofurazone	100	$0.35
(9.3%)	500	1.75
Oxytetracycline	500	3.75
	1,000	7.50
Terramycin Fremix	500	2.30
(TM-50D 50 g/lb)	1,000	4.59

* Source: Lightner (see references)
** Argent Chemicals, 1985. This company has also obtained average growth rates of 0.95 grams per week for juveniles up to 6 gram size, and 1.25 grams per week for shrimp greater than 6 grams in size, at densities of up to 70,000 juveniles per hectare. Final feed conversions range from 2.2 to 3.0:1.0. Although these conversions may not prove optimal they are well within economic feasibility.

Table 6
Coastal Land Use in Ecuador (in hectares) in 1983
(Valdiviezo, 1985)

Province	Shrimp Ponds	Mangroves	Salinas
Guayas	52,911	121,463	17,340
El Oro	26,483	24,488	2,520
Manabi	8,376	7,873	163
Esmeraldas	1,595	21,293	4
TOTAL	89,367	175,119	20,028

Table 7
Pond Construction in Sucres Circa February 1984

Land concessions on the mainland	Previously in use	Land clearing 200,000/ha Construction 400,000-600,000/ha
	Undeveloped	120,000/ha
Land concessions on islands	Previously in use	400,000/ha
	Undeveloped	80,000-120,000/ha
Private undeveloped agricultural lands on the mainland	Low land*	60,000-80,000/ha
	High land**	40,000-60,000/ha
Private undeveloped land on islands		120,000/ha

* Below the high tide level.
** Above the high tide level.

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