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NON-TRADITIONAL AGRICULTURAL EXPORT SUPPORT PROJECT

AN ASSESSMENT OF SHRIMP PRODUCTION OPERATIONS IN HONDURAS AND EL SALVADOR

Assignment Number: ST/87-53
Contract Number: 596-0108-C-00-6060-00

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SECTION I

EL SALVADOR/CRUSTACEOS DE PACIFICO

A. Introduction

This work was performed under a contract with La Fundación Salvadoreña Para El Desarrollo Económico y Social (FUSADES) and Crustaceos del Pacífico (Convenio-Divagro/87-127). It was designed to assist Crustaceos del Pacífico (CdelP) in the development of a reliable maturation system in their hatchery. With a functioning maturation system in place the company could undertake further expansion of its intensive production system.

During the last four years, Crustaceos del Pacífico has adapted the Taiwanese technology of high-density culture operations to the Salvadorian environment. High-density culture systems, i.e., those having more than 30 post larvae per square meter, require a more consistent and uniform source of high-quality post larvae. When post larvae are stressed their survival and growth rate is less than optimal. This greatly affects market focus and, hence, the profitability of the enterprise.

During the last fourteen years, I have had the opportunity to work with several firms developing the shrimp culture industry. Most of the pioneering work in the western hemisphere has been carried out by the Ralston Purina Corporation. This company has refined techniques developed at the Galveston laboratory of the U.S. National Marine Fisheries Service for the production of larvae. Experimental fishing in 1975 succeeded in identifying the locations where gravid females could be found in abundance throughout of the year. Females were captured, spawned on boats and reared in larval culture until they were 10 days beyond the initial post-larval stage. At that point they were transferred to ponds for further growth.

In areas where there are no indigenous species of shrimp suitable for aquaculture, or where climatic conditions make it difficult to obtain spawners from oceanic sources, it is necessary to bring broodstock into the laboratory and mature them in captivity. Under these circumstances, maturation and spawning are topics of great interest to those involved in shrimp mariculture throughout the world.

B. Background on the Technique of Induced Maturation

During the last ten years, the Panhouse effect was rediscovered. Research in Tahiti and the Philippines has shown that Penaeid shrimp can be induced to mature, mate and produce offspring in captivity. This was initially accomplished by

pinching off one eyestalk (ablation) of female shrimp grown to mature size in captivity or obtained from the wild. Further modifications of this technique are in use today, allowing for the regeneration of the X-organ, the sinus below the eye, and permitting enhanced regeneration of broodstock.

Male shrimp appear to mature normally in captivity and achieve reproductive capability without such treatment. Studies using ablation have been undertaken in other parts of the world so that eight shrimp species are now known to respond to this technique. These species include Penaeus monodon, P. aztecus, P. setiferus, P. stylirostris, P. merguiensis, P. japonicus, P. vannamei and Metapenaeus ensis.

The success of the ablation technique in stimulating reproduction in Penaeid shrimp is consistent with postulated mechanisms of reproductive control in other species of crustaceans. The sequence of the reproductive process (gonad maturation, egg development, formation and release of mating hormone to initiate mating behaviors, and spawning) is blocked by the presence of an inhibiting hormone synthesized and stored in the X-organ at the base of the eye. Ablation reduces the concentration of the circulating inhibitory hormone. When the titer (or level) of the inhibitory hormone is low, the thoracic ganglion of the brain produces and releases a gonad-stimulating hormone that arouses and maintains the reproductive sequence described above.

The results achieved with the ablation technique are considered a major breakthrough in Penaeid shrimp mariculture. However, early attempts to apply the technique as a practical means of providing the numbers of offspring required for stocking large commercial shrimp farms did not prove totally satisfactory. In some instances ablated female shrimp showed mating behavior but failed to spawn. The numbers of eggs spawned were often considerably fewer than those from wild-caught spawners. Hatching rates were frequently low and at times the hatched larvae did not survive the larval period. Although such observations appear to point to limiting nutritional factors, eyestalk ablation performed prior to the completion of other essential events (such as storage of adequate levels of high quality lipids, yolk development and DNA formation) disrupts the timing and sequence required for successful reproduction. This comes as no surprise since reviews by Kleinholz and Adiyodi/Adiyodi describe numerous other endocrinological functions also found in the eyestalk's X-organ. Therefore, eyestalk ablation removes not only the source of the gonad-inhibiting hormone, but also the source of a number of other metabolic-regulating hormones which play an important part in reproduction. These results emphasize the need for a more basic understanding of both the factors and mechanisms that control reproduction, as well as the processes involved in the formation

and maturation of eggs in the ovary.

Emphasis on nutrition initially focused on using live or freshly-killed "natural foods," such as adult Artemia, blood worms and shrimp, and on an optimal set of cultural conditions. Several studies have verified that fresh marine foods of high nutritional value and compounded diets, changes in salinity and temperature, photoperiod both artificial and natural, and the selection of reproductive shrimp, affect the reproduction potential of the enterprise.

Classical nutritional approaches have investigated the relationship between the process of reproduction and the concentration of protein, lipid, and carbohydrate in major tissues, e.g., hepatopancreas, gonads, and muscle in comparisons between shrimp that are caught in the wild and those cultivated under various environmental conditions. A key focus in these studies is on determining dietary deficiencies by examining the lipid components, particularly phospholipids, and dietary fatty acids of various tissues and of eggs from wild stocks compared with patterns obtained from shrimp reared in captivity.

It is imperative to control light, as the release of the endocrine reproduction occurs in the eyes. By controlling photoperiod, intensity, wavelength and duration, one is able to mature female Penaeid shrimp at non-commercial levels without resorting to ablation.

The use of eyestalk ablation short circuits the normal ovarian development process, making it essential to use artificial insemination to obtain required larvae. Animals older than 10 months and weighing more than 60 grams normally mature two molt cycles after ablation, a period of up to two months.

C. Maturation Systems in Crustaceos Del Pacifico

The work at Crustaceos del Pacífico hatchery is centered on two small-scale systems for maturation. The Penaeus stylirostris system is composed of four rectangular four meter tanks. Each is stocked with 40 to 45 animals of 45+ grams in size, recently brought from their pond system. The tanks have a male to female ratio of 1:4. When the work began the shrimp were in a very stressed condition. Most notable were several shrimp with necrosis of white tails. Most had a dull color and some had lesions that were not healing.

The Penaeus vannamei system is composed of two five-meter round tanks stocked at 40 to 45 female shrimp, each weighing 50 to 60 grams. The male shrimp are held in an a rectangular outside tank of 20 square meters. These shrimp were in better condition than the P. stylirostris, having been brought to the laboratory over six months earlier than the other species. At

first viewing they were not in optimum condition; they had shown signs of maturing earlier, as noted by eggs in the tail, but this condition did not last longer than four days and the eggs were always reabsorbed.

D. Demonstration of the Ablation Technique

I began by demonstrating the eyestalk ablation technique. Large females from one tank in each system are captured and held underwater. The eyestalk is held between the thumb and forefinger and the eye is cut using a scapel or razor blade. Once the incision is made, the eyestalk is pinched so that the contents of the eye and that of the X-organ located just below the eye are seen in the water. The animal is then released into the tank with a minimum of stress. Response is noted via the following signals: a change in carapace pigmentation density, i.e., lighter color; higher feed intake; and greater swimming activity. The process can be repeated if the shrimp do not respond. Two months following ablation, the shrimp may have to be reablated to further remove the gonad inhibitory hormone so as to allow complete gonad development for the second spawn.

E. Illumination

Photoperiod is important to the maturation cycle and must not fluctuate daily or a decrease in fecundity will result. Intensity is important for development of the germ cell; if it is too low, it will delay the egg development process. *Penaeus stylirostris* will mate naturally at nearly any intensity of light but *P. vannamei* are very particular, seeming to prefer low-light or completely dark conditions in order to mate in captivity. *P. monodon* develops and mates in either a low-intensity or a continuously dark condition and is the least critical of species from a maturation standpoint. Lighting supplied to these two systems seemed adequate. The *P. vannamei* were held in dim to dark light and the *P. styl.* were held in dim light.

F. Tank Management

The scale of the present maturation systems in Crustaceos del Pacifico is too small to supply nauplii consistently to meet the needs of an expanding commercial operation. The systems used in this hatchery are adaptations of larval production tanks and are not optimal. A more workable tank system will have to be built if production of nauplii from maturation is to be carried out on a continuous basis.

Preferred stocking densities for the three species are 250 to 300 grams per square meter of tank space with a male to female ratio of 1:1 or 2:1. As *P. monodon* are much larger brood animals, they are stocked at one to two per square meter as opposed to two to three per square meter of *P. vannamei* or *P.*

stylirostris. It is also preferable to use round shallow tanks in an area separate from the hatchery where all environmental factors can be controlled. It is important to note the difference in the carrying capacity of a tank four meters in diameter as opposed to five. A four-meter tank provides 12.5 square meters of bottom surface area, which translates to 38 animals of 80 gram sized P. vannamei or P. stylirostris. A tank five meters in diameter with a 19.6 square meter surface area will carry 58 animals of the same size or an increase of 34 percent for a tank addition one meter in diameter.

An efficient system of female utilization is necessary in any new system so that non-producing females are not kept in tanks for very long. The focus in developing such a system should be on scheduling and proper scaling of the operation in relation to production needs.

Regeneration of the broodstock will have to be integrated into any expanded operational process. The maturation capacity of an animal depends on the quantity and quality of its lipid reserves. The capacity of P. monodon is much greater than that of P. stylirostris or P. vannamei; thus, fewer animals are required to provide more nauplii given the size and fecundity differences of the three species. Given the same nutritional base, the regeneration time for P. monodon is nearly twice as fast as for P. vannamei or P. stylirostris. This, in turn, means that the reproductive life of P. monodon in a maturation facility is much shorter than that for either P. vannamei or P. stylirostris

As noted above, the background marine culture experience in this hatchery seems to be based on knowledge of Penaeus monodon and fresh water shrimp. Thus, several infrastructural requirements were not part of the original construction and operational process. Presently, cold water (<25.5 oC) outside tanks are used for male P. vannamei and warm water (> 28.0 oC) inside tanks are used for females. The shrimp therefore are regenerated at high temperature, or brought to a higher nutritional status with respect to their lipid content. In the future, animals will be brought into the hatchery only after having been conditioned in outdoor tanks on the hatchery grounds. The length of time spent in these tanks will depend on the response noted in the shrimp; however, it should be remembered that Penaeids require at least a 10-month growing period before they can reach optiminal maturation use. It is possible to use animals younger than 10 months for maturation, but these will produce nauplii of inferior quality and a lower yield. The biologist in charge of a hatchery is responsible for the uniform treatment of shrimp in an attentive manner; the person overseeing C. del P. is doing an outstanding job. However, a system devoted exclusively to the maturation process must be developed for, then taught to, the hatchery workers.

A distinctive characteristic of P. monodon larvae is the decreasing survival rate of a given female's successive spawns. This reaches a peak at the fourth or fifth spawn, from which point the larvae are not worth culturing and the female is best removed from production. This characteristic is directly related to the female's regenerative ability and high fecundity rates, as the assimulation and metabolism of lipid is extremely high and is not met by the diet. This characteristic lowering of larval viability and performance in culture with successive spawns is also true for both P. vannamei and P. stylirostris.

From a practical stand-point, maturation diet formulation must be based on fresh feedstuff containing high levels of phospholipids and sterols. Prior to preparation, the values of major nutrients to be compounded in the diet must meet the parameters listed below. Known nutritional values of marine products were used to establish an optimun practical diet. In the future, products to be used in practical or compound diets should be analyzed beforehand for their effectiveness; also, cheap alternatives should be identified.

Parameters for an Ideal Maturation Diet:

1) The crude protein content should be 50+percent.

2) The defined level of each essential amino acid compounded in the protein part of the diet is calculated as a ratio using the following formula.

Methionine Content of the proteinous fraction of the diet	x	Essential amino acid ratios to methonine content of the proteinous fraction from Clam, Oyster,Shrimp or Fish ovary.

The amount of each essential amino acid in the proteinous fraction from a diet should be greater than the corresponding defined level.

3) A crude fat level of 10+percent,in the form of ethyl ether extracts.

4) A minimum phospholipid level of 6 percent, in the form of polar lipid.

5) A sterol level of 1.5 percent, in the form of total sterol.

6) Carbohydrate at approximately 20 percent, in the form of glycogen.

7) Minerals: approximately 2.5 percent, in the form of phosphorus and about 1.5 percent as potassium.

Phospholipids, or phosporalated fatty acids, particularly Arachidonic, Docosahexaenoic and Eicosapentaenoic, are essential to growth, initiation and completion of maturation. These three lipids are found in high concentrations in the polychaete Glycera dibrachiata, adult Artemia, squid, clams, oysters, mussels, reproductive tissues of other aquatic animals, and nervous tissues of terrestrial animals. Penaeid shrimp show a very limited capacity to chain elongate and desaturate 18:3 w3 and 18:6 w6 fatty acids to C20 and C22; these longer chains are essential to the formation of new tissue and must be provided through dietary sources. These essential lipids are most abundant in algae-consuming bivalves and adult Artemia, as they are able to desaturate long chain fatty acids, a prerequisite to the formation of phospholipids.

Fresh foods high in essential lipids were fed (at a minimum level of 10 percent of each tank's biomass) at three or four intervals per day. This was initiated when the work began so as to provide continuous nutrition to maturing adults and to insure the high quality of eggs produced. As assimilation of the diet increased, noted by improvements in the growth and condition of the animals, the amount of food during the first five days was increased. During the next five days, the molt frequency increased and the condition of the animals improved dramatically. Increases in lipid content, noted almost immediately after the initial feeding, continued. After 15 days of feeding, several P. vannamei exhibited circuling behavior; furthermore, the beginnings of lipid deposits in the tail's ovary was noted. To date, this set of animals has not yet reached full ovarian development but is proceeding well and should reach full development soon. A shrimp older than 10 months and larger than 60 grams normally matures two molt cycles after proper conditioning, which can take as long as two months.

Species Comparison

Condition	Species		
	Van	Styl	Mon
Optimum Temperature	28-30oC	27-28oC	28-30oC
Optimum Salinity	32-35	32-35	28-30ppt
Captive Maturation	Yes	Yes	Yes
# Eggs/Female	120,000	250,000	1,000,000
% Fertilization	0-80	0-90	0-90

SECTION II

EL SALVADOR/AGROMARINA DE EL SALVADOR

A. Introduction

This work was supported by an extension of a contract between La Fundación Salvadoreña Para El Desarrollo Económico y Social (FUSADES) and Agromarina de El Salvador(Convenio-Divagro/87-127 and subsequent modifications as noted in DA MMB/409 mq/87). This contract was further modified to assist Agromarina de El Salvador, in the continuing development of its pond production management system. Specifically, the work would focus on the following areas: pond preparation; pond fertilization; water quality management; and the feeding of nursery and grow-out ponds.

B. Pond Preparation

The pond bottom should be dried as completely as possible. If small pools remain, they should be chlorinated using a concentration of 20 grams per gallon of commercially-available chlorine to assure that the pond is free of predatory organisms and non-productive bacteria. This will evaporate during the next two days. Any small pools that remain following chlorination must be checked for bacteria.

C. Pond Fertilization

When the pond bottom is dry enough to allow a tractor to operate on it, the soil should be turned over so as to be aired. At this point several pretreatments can be given depending on the fertility and acidity of the bottom. In order to apply appropriate levels of fertilizer and/or pretreatments, it is necessary to know the pH or the relative acidity or alkalinity, as well as the concentration of phosphate in the soil.

If the pH of the soil in a saltwater pond is low, i.e., 4.0, it is likely that phosphate is limiting the production of phytoplankton during the last turnover and, thus, may have contributed to the low productivity. Inorganic phosphate increases the productivity of phytoplankton which subsequently increases the alkalinity of the water. This increase in pH, in turn, limits the production of zooplankton.

In soils with a low pH level, an application of up to one ton of $CaCO_2$ per hectare can be spread in the deepest parts of the pond. Greater amounts of calcium should not be added, at any one time, doing so may increase the hardness of the water in the layer closest to the bottom of the pond to the point where molting in shrimp may be inhibited.

1. Inorganic Fertilizers

The relation between nitrate and phosphate in a fertilizer determines to a large degree the types and species of algae and diatoms produced. A ratio of 20:1 N/P results in the production of "Lab-Lab" with a turbidity reading of 25 to 30 cm. A ratio of 3:1 favors the production of benthic diatoms, while a ratio of less than 3:1 favors the abundance of phytoflagelates.

Each pond bottom has unique nitrate and phosphate requirements and its total inorganic fertilizer requirements should be determined on a regular basis. The pH of the soil and the salinity of the water can greatly affect the availability of these elements. The concentration of phosphate should not exceed 0.1 ppm; to do so can cause extreme fluctuations in water quality, variations which may not be controlled within the present pumping capacity.

The best way to apply inorganic fertilizers is to use a liquified form or to put the appropriate dose in a fine mesh bag hung on a pole close to the freshwater entrance of the pond, allowing it to dissolve slowly. If there is a notable change in the algae's color or density, the remaining fertilizer can be removed reducing the fertilizer's effect without having to flow an excessive amount of water.

Some shrimp producers in Ecuador have substituted feeds for a weekly program of fertilization in ponds with salinities of greater than 25 ppt. They have applied 20 Kg of Urea and 7 Kg of P2O5/Ha., with harvest densities of one to two shrimp per M2, sized U 21-25, and a total production of 1 1,200 Lbs./Ha./4 1/2 month period.

2. Organic Fertilizers

Local sources of chicken, pig, cattle manure and residual products from agriculture have been used as organic fertilizers with varying success. There are two ways to deliver feeds in commercial shrimp culture. One can formulate feeds in El Salvador at a cost of between 60 to 100 colones per 100 lbs or the use of natural foods can be increased to produce shrimp with very little on no direct feeding.

Bacteria and algae form the basis of the marine pond ecosystem. The quality of these organisms will determine the digestive capability and the quantity of essential growth factors that are available to the shrimp. Cattle manure contains levels of inorganic fertilizers at levels appropriate for optimum algae and phytoflaglate production. Cattle manure also contains a blend of bacterial flora fine-tuned to digest carbohydrates. This exogenous source of carbohydrate digestive enzymes can be

used by the shrimp porducer to assist in the digestion of pelleted feeds containing high levels of low-cost carbohydrates.

Fertilizer/Food	Percent N Ratio P
Cattle Manure	2.36 0.97
Chicken Manure	15-18 1.0
"Lab-Lab"	20 1.0
Benthic Diatoms	3.0 1.0
Phytoflagelates	2.5 1.0

The application of organic fertilizers is dependent upon the salinity of the water. In estuarine waters, 15 - 25 ppt approximately 200+ lbs/ha/week can be used; in waters with a higher salinity, 25 to 40 ppt, as much as 700+ lbs/ha/week, can be used. The principal effect is in the production of microbenthos and bacteria, both of which are a major source of high quality foods and can assist the shrimp digest carbohydrate for energy.

There are many forms of applying manure to ponds. I strongly suggest that the manure be washed in a 55 gallon barrel and allowed to settle. The remaining liquified solution should be applied to the pond. It may also be placed in burlap sacks that are, in turn, placed in the pond. After they have had their effect on algae production, the cellulose can be removed. The direct application of manure to the bottom of the pond can increase the acidity of the surface layer of water directly above the bottom, where shrimp feed.

D. Water Quality Management

The optimum working water level depends on the season and its effect on pond temperatures, which should be maintained at between 27 and 32° C. The water level should be raised slowly to allow the diatoms to grow, and painstaking measures should be taken to assure that predators are not allowed to enter. If the pond is level or has a minimal slope it should be filled to approximately 30 cm depth. After a bloom is noticeable, it can be raised another 30 to 50 cm. In the rainy season or to accelerate algae production, a well-filtered syphon from an older pond to the newly-filling pond can be used. Precaution must be taken to filter the incoming water so that predators are not allowed to enter.

The management of water depends on the seeding practice employed. The seeding can be direct or indirect using nursery ponds. Nursery ponds are used when the seed is very small (PL 5 to 20). Post larvae can be stocked at 100 to 200 per square meter. They are generally maintained at these densities in the nursery until they reach 0.5 to 1.0 gram size. They are then transfered to grow-out ponds until they reach harvest size. The transfer usually occurs at night when the temperature is less than 28° C. The transfer of shrimp in higher temperatures can contribute to excessive mortality.

Direct seeding of grow-out ponds with small seed can be done, temperature permitting, while the pond is slowly filling. The densi of seed depends on the predominant species available and the size of the seed captured.

Potential of Extensive Production System

Dry Season using Penaeus stylirostris

1) Stocking at two post larvae per square meter requires 20,000 Pls/ha

   90% survival
   73% Tail weight
   25 gram size shrimp = U16-20
   @ $8.10 per pound

   $5,860.90 earnings per hectare per five month period

2) Stocking at five post larvae per square meter requires 50,000 Pls/Ha

   60% Survival
   73% Tail Weight
   25 Gram Average Size = U16-20
   @ $8.10 per pound

   $9,786.17 earnings per hectare per five month period

Rainy Season using Penaeus vannamei

3) Stocking at five post larvae per meter square requires 50,000 Pls/ha

   90% Survival
   65% Tail Weight
   18 Gram Average Size = U36-40
   @ $3.20 per pound

   $3,711.01 earnings per hectare per five month period

4) Stocking at 10 post larvae per meter square requires 100,000 Pls

70% Survival
63% Tail Weight
18 Gram Average Size = U36-40
@ $3.20 per pound

$5,595 earnings per hectare per five month period

Water is not exchanged in a recently seeded pond. Water exchange may not be necessary until the shrimp reach 3 Cm size. This, of course, is dependent upon the concentration of algae and the suspension of clay in the water, the time of day the reading is made, as well as the water color. The various color possibilities include the following:

Water Color Indications of Pond Condition

- Grey: This indicates that there are no algae or diatoms in the tank. The water exchange should be increased.

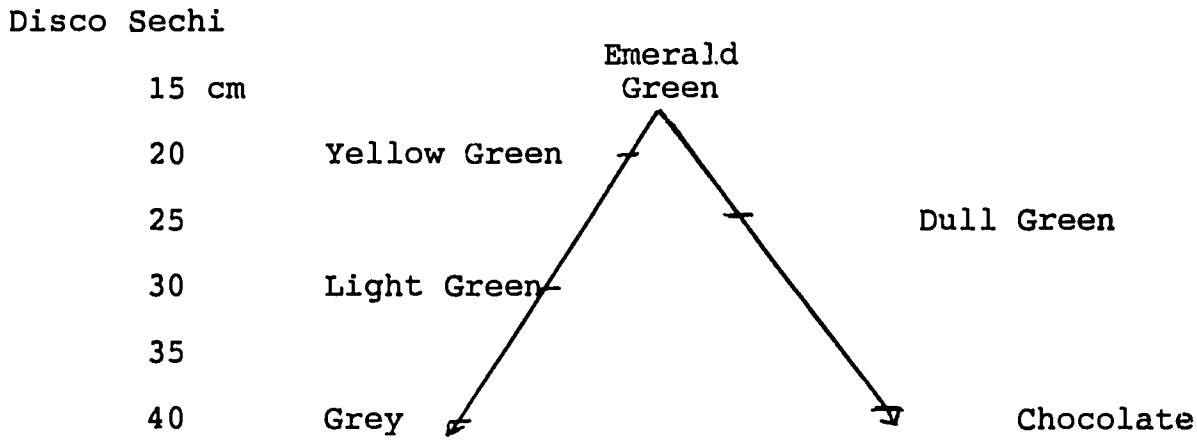
- Light Green: This is a very acceptable color, as it indicates a lightly dense diatom level.

- Yellow Green: This indicates that the algae is in a state of transition. The water exchange should be increased, as low oxygen levels can result.

- Emerald Green: The concentration of algae is extremely high, and the situation is dangerous, which could result in a crisis if heavy water exchanges are not made.

- Dull Green: This indicates that many algae have begun to die.

- Chocolate: Appears after a critical period has passed and indicates that there are dead algae in the tank.



The exchange of water should be held at one to three percent per day until one of the following situations occurs:

1) Two succeeding days with oxygen levels lower than 2.0 ppm in the morning or one day with dissolved oxygen levels below 5.5 or greater than 13 ppm in the afternoon during this time.

2) A pH of 9.0 or greater during the afternoon

3) Water the color of black coffee ("cafe tinto")

4) Shrimp at the surface in the earling morning.

Until situations such as these occur the flow rate should be maintained at a low level. If a water exchange of 15 to 25 percent of the tank is not possible, then the alternative is to work at preventing the occurrence of a toxic situation.

E. Feeding in Nursery and Grow-out Ponds

The supplying of a pelleted feed is not necessary utilizing the pond management practices described above, as the nutritional needs of the animal stocked at the suggested densities will be met by natural food sources. Before one increases densities, a clear understanding of how that decision will increase costs must be accepted by the pond manager. There is a delicate balance between natural food organisms and the density of shrimp in a saltwater pond. As the density of the shrimp is increased, the growth rate and, subsequently, the harvest size is reduced. It is far better to harvest 700 lbs of U16-20 @ $8.10 /lb than 1,400 lbs of U31-35 @ $3.10 /lb. Not only is the gross cash flow greater but lower stocking densities reduce infrastructural, maintance, feed, pumping and management costs.

What Do Shrimp Eat?

Habitat Benthos - Pelegic	Size of Food Organism (um)	Size of Shrimp
Bacteria	1 - 10	Zoea - Post Larvae
Diatoms	5 - 100	"
Yeast	50+	"
Fungi Algae	100+	"
Periphyton	150	Post Larva Juvenile
Copepoda	"	"
Rotifers	"	"
Nematodes	300	Juvenile - 4 Grams
Polycheates	500	4 Grams - 14+ Grams
Pelleted Feeds	Variable	10+ Grams
Bivalves	"	14+ Grams
Gastropods	"	"
Post Larvae	20+	"

Without an exogenous source(s) of digestive enzymes the amount of animal protein in a diet to provide optimal growth increases with size. Understanding the effect that exogenous digestive enzymes can have on shrimp digestion and assimulation of essential growth factors can allow the producer to reduce feed costs significantly.

In the extensive culture system two diets should be used. The first is used when the pond is seeded. After the pond is given a dose of liquified manure to enhance bacterial digestion, live yeast with or without can be applied. The quantity used depends on the density of the shrimp, their size and the availability of other feed organisms in the pond. Throughout this diet, the shrimp's digestive tract and gills should be checked daily, so as to note any change in the feed intake. If the shrimp are not feeding, the water quality and pond bottom management practice(s) employed in the pond must be studied.

After the shrimp reach 14 grams, or when the growth rate of the shrimp begins to slow down to less than one gram per week, a pelleted feed should be used. I suggest that glutenous products, such as corn, be precooked using an alkaline hydrolysis, and that this be added to the rest of the feed just prior to pelleting. Both fibrous feedstuff and minerals should be removed from the feed. If a rudimentary feed mill is available, the head temperature should be checked so that the pellet is cooked a sufficient length of time so as to allow the shrimp to have contact with the feed for at least four hours. This can be done by repelleting the feed or by adding fermented sorghum.

Each feedstuff must be evaluated for its mortality rate in shrimp. This can be done by adding large quantities of one feedstuff to another or can be done by adding a small but constant amount of each feedstuff to a glass containing three to five shrimp and recording the length of time it takes to cause stress, color change or death.

To improve the pellet's water stability, the following steps should be taken:

1) All ingredients, with the exception of rice polishings, should pass through a hammer mill screen not larger than 1/16" thick.

2) Add fish oil as a topping to the pellet just before feeding.

3) Use an organic binder of Wheat clear (local pasta flour), Nutribinder or fermented sorghum (not less than 5 percent), and precooked corn to maximize effectivity of the starch content. Use yuca if available.

4) Pellet the feed twice, increase the width of the head of the pelleting machine or use steam, if possible.

The following formulas are suggested:

Ingredient	15%	20%	25%
Corn	30	29.8	25.1
Wheat	28	28	24
Rice	27	28	24
Fish	6.3	6.7	19.5
Organic Binder	5	5	5
Vitamin C	1	1	1
Vitamin Mix	0.5	0.5	0.375
Fish Oil Topping	1	1	1

SECTION III

CONCLUSIONS

Crustaceos del Pacífico

Problems

- o Only one person in charge of all aspects. If he leaves or becomes ill the earnings will be affected.
- o Hatchery experience of technician is with freshwater shrimp and Penaeus monodom. New technicians need to be brought in and a new hatchery must be constructed. I strongly suggest that Ecuadorans be asked to participate.
- o The pond system can operate with wild seed stock, eliminating the expense of a hatchery. To do so, post larvae collection techniques will have to be improved.
- o At higher densities, diseases are beginning to appear. This requires continuous attention by experienced personnel.
- o Growth of the enterprise seems to be limited to internal funding sources and to the same location. Reasons behind such choices need to be explored.
- o There is an eight meter lift from sea to pond system and narrow access to the sea. The limited pumping capacity results in restricted productivity.

Potentials

- o 3,000 pounds of tail weight per 8,300 square meter pond is now standard. Tail weight of over 10,000 pounds per 8,300 square meter pond twice a year may be possible.
- o Best administrative system of all shrimp farms in operation.
- o Company has established a smoothly running integrated operation.
- o Farm, hatchery, offices and partners are all in or near San Salvador.
- o Production systems in non-conflict zone.
- o Country-wide expansion is possible using this system as it fits within the government's agrarian reform plans.

Rey del Gulfo

Problems

- o Productive capacity of only 17 hectares.
- o Must expand the system to 50+ hectares.
- o Problems with the capture of post larvae. This is tied to improper techniques used by staff and not to the availability of post larvae.
- o Present production practice is to stock post larvae and juveniles at various times, rather than all at once. This gives better results but is not indicative of the true potential of the enterprise.
- o Lack of understanding how ponds are operated.
- o Located in a conflict zone.
- o Now stocking at 10 post larvae per square meter, yielding approximately $38,454 per five-month culture period.

Potentials

- o Both owners participate in the enterprise, the work of one complementing that of the other.
- o The hatchery is located on an island. (Isolation in this business has its advantages.)
- o $49 to 60,000 per five month period at five post larvae per square meter may be achieved.
- o Ponds are filled without pumping. The present practice shows that the system can be operated 15 of 30 days each month without pumping.

Agromarina de El Salvador

Problems

- The owner's participation in the enterprise has to be more direct and consistent.
- Pond management practices need to be improved.
- Water is pumped eight meters from sea to pond. The water distribution system needs to be improved so that all ponds receive fresh water and a minimum of dead areas remain in the ponds.
- 33 of 30 hectares appear to be operant. The rest are either too shallow or are poorly fed by fresh water.
- High operating costs; if pond management improves, these costs can be reduced.
- Management doesn't seem to be internally driven and there appears to be no clear plan for making the enterprise profitable.
- All ponds must be pumped to receive water and the sea source of water doesn't contain high nutrient levels. Fertilization is necessary to maintain pond productivity.

Potentials

- If pond management and minor construction improvements are made, could earn approximately $86,590 per five-month period at a stocking density of five post larvae per square meter.
- Located close to the city.

Monte Verde, La Union

Problems

- The owners do not participate directly in the enterprise.
- All personnel have limited operational experience.
- Poor administration.
- Poor understanding of how to use enterprise to make it function at the optimal capacity.
- Prioritization - the owners must refocus their efforts so as to maximize profitability and cash flow.

Potentials

- Good agronomist running day-to-day operations.
- Post larvae fishermen have experience and are able to capture large quantities of post larvae in a short period of time.
- Post larvae examined during this visit had a high level of *Penaeus vannamei*.
- 58 hectare productive capacity without pumping during 15 days per month.
- Potential earnings of $119,577 per five-month period without pumping. This could double if the pumps are operating.

CALENDAR

I. ADVISORY ASSIGNMENT #1, AUGUST 9-15

08/09/87 -	Arrive San Salvador, El Salvador Met with Mr. Ramon Hsu, director of Crustaceos del Pacífico.
08/10/87	Met with Mr. Pedro Urquilla, coordinator, ASPENT Later met with Crustaceos del Pacífico personnel and Mr. Jorge Ramos, Ejecutivo Corporativo, Banco Cuscatlan, to refine work plan and assess needs.
08/11/87	Traveled with Mr. Ramos to Agromarina de El Salvador shrimp farm. Reviewed the operation with the owner, Mr. Manuel Castillano, and made recommendations to improve productivity, feeds and feeding, pond management, post larval collection and identification techniques, as well as pond construction needed to improve operation.
08/12 - 13	Traveled with Mr. Ramos to Camaronera Rey del Gulfo, on an island near La Unión. Met with Mr. René Goodall and made recommendations on post larvae collection techniques, management practices, feed and feeding practices and pond seeding practices which could optimize product entry into the U.S. market.
08/14	Worked with Mr. Ramon Hsu on shrimp pond growout dietary and maturation problems. Set guidelines for maturation diet and helped group work through the development of an appropriate maturation diet. Made recommendations to improve efficiency of pond diets.
08/15	Traveled with Mr. Hsu to the Crustaceos hatchery and gave practical demonstration of eyestalk ablation techniques. Ablated one tank of *Penaeus stylirostris* and one tank of *P. vannamei*. Reviewed maturation management practices and refined the maturation diet development.

II. ASSIGNMENT #2, AUGUST 16 - SEPTEMBER 18

08/16 (Monday) Began new contract with Crustaceos de Pacifico through FUSADES, a 15-day extension of the previous work to follow-up on developments and make modifications as needed to further develop the Crustaceos del Pacifico maturation system.

08/17 Met with Mr. Mario Molina of FUSADES and Mr. Hsu of Crustaceos del Pacifico to sign contract. Met with Mr. Ramos of Banco Coscuatlan in the afternoon and continued discussions on nutritional requirements of shrimp with Mr. Hsu.

08/18 Worked with Mr. Hsu on further refinements to maturation system and feeding practices.

08/19 Traveled with Mr. Hsu to the Crustaceos del Pacífico laboratory to review ovarian development in female shrimp. Three shrimp showed some development but none had developed beyond the first stage. The shrimp appeared to be too young to allow rapid and complete maturity. All shrimp had full gut and intestines; feed was increased in all tanks.

08/20 Discussed further refinements of the maturation system and practices with Mr. Hsu and Crustaceos staff. Made plans to take sourcing trip(s) to catch adult spawners.

08/21 Female shrimp began to increase deposit of eggs into the abdomen. A small "V" shaped area just posterior to the head began to appear. Intestine was full and increasing in size, so the feed was increased. Head area in all shrimp showed increased deposits of lipid. None were reabsorbing.

08/22 Shrimp showed further development of the plecenta or "V" area posterior to the head. None reabsorbing and Styl appear to be moving faster toward full development than P. van at this point.

08/23 (Sun) Travel with Mr. Hsu to the shrimp farm to review the present status of their pond situation. Checked shrimp disease and nutritional status. Made modifications in the feed and recommended that they treat tanks showing signs of Epistylistris and Lucotrix with 4.5 grams of

active ingredient (Erythromycin) per 100 lbs of feed for a minimum of ten days feeding.

08/24 Met with Mr. Jorge Ramos at the bank to discuss a short course for shrimp producers the upcoming Saturday (08/29). Mr. Ramos had made arrangements for the attendance of approximately thirty people. The lecture would focus on post-larvae capture, pond management and control of water quality.

Later the same day, I met with members of RDA International who were working with FUSADES to help them establish a nation-wide program to develop the aquatic culture potential development in El Salvador. I gave them a copy of my May trip report and a couple hours of insight based on my short experience with shrimp producers in this country.

08/25 Traveled with Mr. Hsu to the Crustaceos hatchery to review feed and feeding practices and to assess effects of previous diet and feeding regime on ovarian development in the shrimp.

08/26 Traveled to Camaronera Monte Verde with Mr. Ramos. The bank was particularly interested in making the farm produce a cash flow. When we arrived the farm had only 12 stocked hectares and was filling its ponds with the tide. In discussions with Mr. Ezequiel Miranda, agronomist-manager, and Mr. Roberto Courtade, co-owner, we determined that 58 hectares were available to be filled by tide and fresh seawater, these could be exchanged 15 out of 30 days per month. 58 hectares, at a stocking density of 5/M2, could yield 2.5/M2 of U 36-40 and 41-50 count tails per meter square. A yield of 36,250 lbs of tails, valued at $108,750.00, could be expected in five to six months. This recommendation was followed. Construction priorities were restructured so that the pond could be filled using the harvest doors and subsequently stocked at low densities.

08/27 I met with Mr. Mundo, president of the Banco Cuscatlan. He was particularly interested in my opinion as to the potential solvency of the four shrimp farms currently being funded. At present, the bank has 1.4 million colones in loans to these enterprises. It now gives technical assistance to these enterprises but Mr. Mundo

strongly feels that they should stand on their own. He was at present unsatisfied and wanted to increase cash flow.

08/28 I met with Mr. Frank Scronski of USAID/El Salvador to discuss the shrimp farming potential in the country. We discussed at length the potential of developing a nationwide program for small-scale, high density shrimp production, particularly as it could utilize retired military personnel.

08/29 Presented a lecture at the bank to approximately 30 shrimp producers and those who want to begin development. Much of the afternoon was taken up by questions and answers sessions with attendees.

08/31 I began a new contract with Mr. Manuel Castellanos, owner of Agromarina de El Salvador. The objectives of this work included the preparation of ponds, feeding in the nursery and grow-out tanks, water and algae management, and fertilization of the ponds.

09/01 Met with AID to amplify discussions on the potential to develop a nationwide program of small-scale, high density shrimp production. AID appeared interested in the idea and discussions of how a viable system could be set up. They requested a business plan; a copy of the one developed by Crustaceos del Pacifico was reviewed.

09/02-04 Worked with Mr. Castellanos to prepare ponds for stocking. Ponds were drained, chlorinated to sterilize bacterial population and calcium carbonate was added to raise the pH of the pond bottoms.

09/05 Began fishing for postlarvae and juvenile shrimp in the Bara de Santiago estuary. Taught techniques of capture, species identification and separation, transport and pond side acclimation in preparation for stocking of nursery and grow-out ponds.

09/07-13 Fished for post larva and juvenile shrimp in estuaries but focused majority of fishing effort on open sea postlarva collection using bi-lateral surface plankton collection nets. Focused efforts on species identification and transport to minimize mortality.

09/14-17	Continued postlarva capture and seeding until we had stocked 13 hectares.

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