PN-ABL067

RDA International, Inc.

P-145

76755

AN ASSESSMENT OF THE PRESENT STATUS, COMPETITIVE POSITION, AND LONG-TERM POTENTIAL OF THE BELIZEAN SHRIMP INDUSTRY

Presented to
USAID/Belize
and the
Government of Belize
Ministry of Economic Development

30 June 1989

Prepared by:
Donald Sweat
Kelly Sackheim
Sjef Van Eys
RDA INTERNATIONAL, Inc.
under Contract No.
505-0012-C-00-9308-00

RDA INTERNATIONAL, INC.
801 Morey Drive
Placerville, California 95667
Telephone: (916) 622-8800
Facsimile: (916) 626-9371
Telex: 383656 RDA

ACKNOWLEDGEMENTS

This study could not have been completed without the cooperation and assistance of many key individuals in Belize. Mr. Art Villanueva, USAID Project Officer, and Dr. Fred Mangum, USAID Advisor to the Ministry of Economic Development, provided important background information and introductions to individuals working with shrimp mariculture in Belize. Mrs. Yvonne Hyde, Permanent Secretary of the Ministry of Economic Development, actively promoted the realization of this study and enlisted the cooperation of other government personnel.

The comments and information obtained in many meetings with the staff of the Aquaculture Unit of the Ministry of Fisheries, including Messrs. Vincent Gillette, George Myvett and Dwight Neal were invaluable. RDA would also like to thank Winston Miller of the Belize Export Investment and Promotion Unit, and Sharon Bean and Linda Bautista of IESC, for sharing information about seminars and services which have already been provided to shrimp producers in Belize.

Frank discussions with managers and other staff of all the shrimp farming operations which are presently producing or under construction in Belize were absolutely essential to the assessment of their situation and development of recommendations. These individuals include: Mr. Charlie McIntosh, Mr. Victor Quan, Dr. and Mrs. John Snell, Dr. Benard Colvin, Mr. Masudul Bari, Ms. Linda Cardelli, Mr. Bill Thornton, Mr. Kenneth Bristow, Mr. Calvin Goldsmith, Mr. Russell Allen, Mr. Thomas Grimshaw, and Mr. James Hyde. Similar discussions were held with key members of the cooperative associations, including Messrs. Severo Pinto, Robert Usher, Justin Bradley, and Theodore Morales. Many of these persons provided written records of confidential and crucial financial and operating data, and are doubly thanked.

TABLE OF CONTENTS

TABLE OF CONTENTS
(Continued)

LIST OF TABLES

1.0 EXECUTIVE SUMMARY

The Government of Belize (GOB) has determined that their official development strategy is to promote exports as the engine of growth, to diversify exports away from a single product orientation, and to develop import substitutes in an economically efficient manner. RDA International, Inc. (RDA) was contracted by the United States Agency for International Development (USAID) to undertake a study of shrimp mariculture in Belize as one industry which could potentially meet these objectives.

The specific scope of work entailed 1) identification of problems and constraints in the existing shrimp mariculture industry in Belize; 2) estimation of Belize's comparative cost position in the U.S. and major CARICOM markets; and 3) estimation of the long-range potential of this industry in Belize. From this information, GOB plans to define an appropriate policy direction for this industry.

The RDA team assigned to this study was comprised of a biologist, an economist, and a market specialist. The team visited all of the shrimp farms in the country, which are in various stages of construction and operation, in addition to meeting with government representatives from the Ministry of Economic Development, Department of Fisheries (Aquaculture Unit), the Belize Export Investment and Promotion Unit, and several fisheries cooperative organizations.

A number of studies of the prospects for shrimp mariculture in Belize have been conducted over the past several years. The conclusions reached and opinions provided regarding the feasibility of shrimp mariculture in Belize have been widely varied. Little scientific evidence was available to the RDA team to support or refute the conclusions of those other studies, so this report is based primarily on direct on-site observations, conversations with present managers, and reasonable assumptions made by the RDA team.

This RDA report has been organized to provide the basis for a government plan of action. It gives a brief background of the shrimp mariculture industry in Belize to date, followed by a more general description of the needs of the industry to permit a better understanding of the causes of the relatively slow development of shrimp mariculture in the country. Sections of the report review the economic conditions in Belize which affect shrimp mariculture. Subsequent analysis focuses on policy measures which GOB may wish to consider (or avoid) for promoting and supporting the industry to generate maximum benefits for the country.

Expatriate investment in shrimp farming in Belize, while it may not be the most profitable opportunity available to the investor, should not harm and could help the country of Belize. To allow private investors to become involved in shrimp farming in Belize costs the GOB virtually nothing. The investors are not using land resources which are being demanded by other productive activities. The country will experience the benefits of having additional activity in the economy, including employment (even if a large proportion of inputs and labor are imported).

Although better conditions may and do exist elsewhere in Central America, climatic conditions are satisfactory and suitable sites are available for shrimp culture in Belize. Why then do existing shrimp culture operations in Belize appear to be less successful economically than those in neighboring countries? There are several possible answers.

First, existing operations in Belize have not always been well managed. Problems noted have included poor site selection, poor design and construction of ponds and facilities, and less than optimum species selection. These problems are not, of course, exclusive to Belize, but they are more easily seen and perhaps more common where the total number of independent commercial operations is small.

Second, the relative lack of supporting infrastructure in Belize (roads, power, cold storage facilities) directly impacts the producer, and increases unit costs disproportionately for the small producer. The capital costs for establishing a shrimp farm in Belize have been estimated by entrepreneurs at US$4,000 to US$8,000 per acre, a range which is double the cost for similar enterprises in other Central American countries and the U.S. The kind of public infrastructure which would benefit shrimp farming would obviously benefit almost any other industry in the area, and the GOB is certainly aware of this. In a world of limited resources, it is a question of when the GOB can financially undertake large scale infrastructure projects in this region. Until such time, costs of production for local shrimp farmers may well remain higher than those for producers in regions where such public facilities are more readily accessible.

Regarding whether GOB should continue to have shrimp farming as a high priority for investment, the prospects for this industry in the long term are not likely to be significantly affected by monetary incentives to investors in the short term. Therefore, a laissez-faire policy containing neither unnecessary restrictions nor costly incentives is recommended.

On the other hand, if Belizeans wish to become involved in shrimp farming in their own country, GOB should take advantage of the experience of the expatriate farmers in the country by funding staff to visit and learn about these farms. Extension services should be available to the small producer.

Since there is not an established aquaculture extension program in Belize at the present time, no data exists at a country-wide level on production experience. During its field visit, the RDA team was not able to collect any significant data from the existing producers' own field work which could be utilized for establishing the parameters of production in Belize. Furthermore, foreign-trained Belizeans in the Aquaculture Unit have not yet had the opportunity to become personally familiar with Belizean conditions. Before an extension program has anything to offer to the small farm, there must be available some relevant information on production conditions in Belize, and extension agents should feel comfortable selecting which international practices would be appropriate for Belize.

The following recommendations should be given serious consideration as government develops its action plan:

- The government of Belize should continue the incentive programs offering concessions for existing farms.

- The existing (and under construction) farms should be allowed continued "freedom to develop" or "laissez-faire."

- The fisheries unit should be provided with additional staff and support to allow at least the present aquacultural section (staff) to become active in the field as true extension personnel.

- Hatchery and processing operations should be looked at as separate, supporting services by agricultural funding agencies.

- An effort should be made to strengthen a loosely organized aquaculture association.

- Farmers should be encouraged to make use of the processing facilities and marketing services offered by the cooperatives.

2.0 HISTORY OF AQUACULTURE IN BELIZE AND UPDATE ON PRESENT STATUS

Attempts in Belize to rear shrimp in ponds began in 1983 and have continued with limited success to the present time. Some of the reasons given for establishing shrimp operations in Belize include the following advantages:

- o cheap, flat coastal land
- o political stability
- o limited bureaucracy
- o active government support and attractive currency regulations
- o proximity to major markets in the USA and CARICOM countries

Despite these important advantages, the industry has shown only modest growth and production has remained well below expectations. Foreign investors already benefit from corporate tax holidays (5-10 years) and free repatriation of profits from invested capital. In order to improve their situation, investors have requested further privileges and incentives, including the recently granted abolishment of the 5% export tax on shrimp, supply of tax-free diesel fuel, and introduction of an industrial rate for electricity, in addition to requests for new (access) roads, electricity connection, and other amenities.

Some of the disadvantages to shrimp mariculture in Belize include:

- o no local postlarvae supply
- o no local feed production
- o absence of local venture capital

Given these positive and negative factors, the question remains whether shrimp mariculturists, with appropriate management, can operate in a manner profitable to themselves and the country as a whole. During the preparation of this report, all of the seven existing (or under construction) farm sites were visited and managers of all operations were interviewed.

2.1 Characteristics of Production in Belize

Various shrimp farms are located from Ladyville, near Belize City, to around Independence, some 90 miles to the south along the coast. There is a great difference in stocking rates among the farms. The majority of growers stock their ponds at densities ranging from 20,000 to 80,000 shrimp per acre, although one farm claims to stock up to 600,000 shrimp per acre. Farms with larger ponds generally begin growout in smaller juvenile ponds to improve monitoring of survival rates and actual stocking densities in the larger ponds. These farms are either being operated, or plan to operate when completed, with relatively standard regimes according to stocking density as described below:

- o Extensive culture - low stocking density, i.e., 12,000-15,000 shrimp/acre, little to no water exchange or monitoring of water, no addition of fertilizer or artificial feed.

- Semi-intensive culture - stocking density higher, i.e., 20,000-75,000 shrimp/acre. Some effort at pond water management through monitoring parameters such as temperature, salinity, dissolved oxygen, and algal density. Some water exchange by pumping, effort to maintain pond's algal bloom by small additions of fertilizer -- either natural (such as animal or bird manure) or purchased (usually "standard" 20-20-20 type). Supplemental feeding with formulated feed several times per day.

- Intensive culture - stocking density high, ranging above 80,000 shrimp/acre. Maximum effort in pond water management by daily monitoring of water quality parameters such as dissolved oxygen, temperature, salinity, and algal density. Daily water exchange by pumping of approximately 10-15%, maintenance of dissolved oxygen levels by aeration devices such as paddle wheel aerators, atomizing pumps, etc. Guaranteed high natural food level in pond by fertilization program featuring natural and/or purchased fertilizers and daily supplemental feeding with assimilated feed rations which may be regulated by monitoring consumption rate or calculated on a percent of body weight basis. (Table 1)

TABLE 1

GROWOUT FEEDING REGIME

Body Weight (in grams)%	Feed Per Day
0-1	10-20
1-2	8-10
2-4	8-9
4-6	7-8
6-8	6-7
10-14	3-4
14-	2-3

At the present time, all except one farm have been principally financed by expatriate (North American) investors. Except for a limited amount of processing which has been done by the fisheries cooperatives, the farms have been largely self-sufficient, relying primarily on imported inputs for needs that cannot be met on site. Delays in obtaining essential inputs because of long shipping periods have been experienced by most farms.

Production results have been disappointing so far. Furthermore, information has been fragmented. Producers are still in an experimental stage, and accurate records have not been available regarding actual input, production, and cost levels. In general, production ranges from 200-1400 lbs./acre/year. Some 540 acres of ponds are currently available for stocking but only 25% are stocked. An estimated 25,000 lbs. of cultured shrimp tails were exported during 1988. Some farms do their own exporting involving a small part of their production, and actual production may have actually reached 80,000 pounds in 1988. In 1987, production was estimated at 50,000 lbs.

The increase to 80,000 lbs. for 1988 stemmed primarily from added acreage and not from improved per acre production.

Species that have been used are P. vannamei, P. stylirostris, and P. schmitti. Currently more farmers are inclined to use P. vannamei because of better production results although postlarvae (PL) of this species has to be flown in from other countries. Results using P. stylirostris were not favorable despite good results with this species obtained by farmers in Panama and Colombia. The local species, P. schmitti, has the negative characteristic of rarely growing to sizes exceeding 36-40 count per pound (headless).

There is one stand-alone hatchery in the country which is not presently operating. One large integrated farm also has hatchery facilities although these have not yet become operational due to lack of adequate broodstock. This farm has imported shrimp naupliI for growing to (PL) stage at their own facilities. Other farms have either purchased PLs from this farm or directly from Panamanian or U.S. sources.

Since mariculture produces a similar product to capture fisheries, it is useful to review both sectors to gain a perspective on the processing and marketing aspects of the mariculture industry. Most shrimp produced in Belize at the present time is wild caught. Wild shrimp only comprises a small proportion of total capture fisheries. The estimated yearly production of shrimp caught by artisanal and industrial vessel activity is estimated at about 365,000 pounds (165 MT). Shrimp is often regarded as an attractive by-catch in the lobster fishery. Species landed are mainly P. schmitti and P. notalis. The first is the dominant species, and a major part of the production consists of sizes 21-25 and 25-30 (headless, shell-on). It is believed that the resource cannot support any substantial increase in fishing effort. Fishermen generally dehead their shrimp on their boats and then deliver the product to one of the cooperatives for subsequent processing and marketing.

2.2 Groups Involved in Shrimp Mariculture

To thoroughly understand the dynamics of the shrimp mariculture industry, it is important to know what individuals and agencies play a role in it and what their priorities are.

Venture capitalists serve as the foundation of the industry. They accept the inherent risks of the operation in exchange for the promise of elevated returns on their investment once initial problems have been solved. These investors wish to have maximum control over the production process, usually by supplying expatriate experts to conduct feasibility studies and manage their projects. Since profitable production is of paramount importance, investors do not wish to be limited by government regulation in procurement of necessary inputs nor in the operation of their business.

Due to the nature of constraints to mariculture in Belize, which are identified in the next section, the entrepreneurs who have decided to attempt shrimp production in Belize have neither come to the country simply looking for maximum return on their investment capital nor simply to produce shrimp. The RDA team found that shrimp mariculture entrepreneurs in Belize have a strong personal commitment to establishing an industry that will not only provide long-range employment for themselves within the country, but will have a lasting development impact on the local communities with whom they work. Unfortunately, this laudable entrepreneurial commitment has not

always been matched by available funding nor specialized expertise, and there have been setbacks in the realization of optimistic plans.

The Government of Belize desires to both regulate and promote the shrimp mariculture industry. The Aquaculture Unit of the Department of Fisheries within the Ministry of Agriculture is charged with monitoring and supporting development of the industry. The unit is relatively new and the limited staff has not yet had much time or funds to begin to implement programs for which they have been recently trained. Expatriate operators appear to be rather skeptical of the capability of the Unit to assist their operations. So long as GOB data collection activities would not unduly hinder normal working operations, there is no indication that operators would not be cooperative. GOB data collectors must develop the trust of all farmers and be particularly careful not to disrupt relations with financial lending institutions and potential investors by reporting inaccurate or misleading information regarding the capabilities of each farm to meet its production goals. Most farms have been quite cooperative to date with data gathering by a number of different organizations, including Belizean government officials, the World Bank, and externally funded aquaculture consultants. The opinions provided regarding the feasibility of shrimp mariculture in Belize have been widely varied, with little scientific evidence presented to support or refute the conclusions of each study. A strengthening of the Aquaculture Unit within the country could provide a valuable service to all producers by fostering realistic expectations of the industry.

The Ministry of Economic Development, in coordination with the Ministry of Finance, manages the program of concessions which most of the shrimp mariculturists utilize to lease land at low rates and to import materials. Expatriate operators have complained that the time limits on tax exemption on profits are sufficiently short that they will not be in effect at the time an investor begins to show a return on his investment. Some operators suggested they would prefer to be routinely given the same tax and concession treatment as agricultural producers rather than having to petition for special concessions.

The Belize Export Investment and Promotion Unit (BEIPU) is a nongovernmental organization which assists investors in becoming established in Belize. Their role related to the aquaculture industry has been primarily limited to providing information regarding government regulations and concessions. BEIPU did sponsor a meeting for people interested or already involved in the industry, with the participation of an expatriate consultant, to discuss the potential for shrimp mariculture in Belize and some solutions to current problems. The International Executive Services Corps (IESC) sponsored a follow-up seminar with another expatriate consultant. Both these organizations expressed interest in continuing to support the entry and success of investors in shrimp mariculture in Belize.

Several investors have imported equipment and labor to have their farms constructed; they have often had problems obtaining spare parts for equipment and keeping construction on schedule. Other investors have delegated construction to non-Belizean contractors: some of these farms have had costly lawsuits when their facilities were poorly constructed or not completed within agreed upon schedules. Another farm manager personally has expertise in earthmoving, and the remainder of the farms have generally employed members of the Mennonite community in Belize to do earthmoving with their own equipment. Assisting any future investors in identifying worthy contractors, and particularly in utilizing Belizean contractors, could be a very useful service of BEIPU.

At the present time, most managers of shrimp mariculture operations in Belize are expatriates. However, a few Belizeans, educated abroad, are also beginning to contribute. Many of the laborers and technicians working with the farms are nationals of other Central American countries, partly due to the number of immigrants residing in the growing areas. Managers have indicated that they would fill all possible laborer and technicians positions with Belizeans so long as individuals who are available conform to working requirements on the farm. Given the relative fragility of a shrimp crop, managers depend on the consistency of their work force.

The Belizean fisheries cooperatives, which already process wild-caught shrimp for their members, have done some processing of farm-raised shrimp. The available processing capacity for seafood in Belize is almost exclusively in the hands of the cooperatives. From the 1987 export figures it becomes clear that lobster is by far their major source of income and consequently priority in processing technology and infrastructure is geared towards lobster. In 1987 lobster exports totaled 470,000 lbs. valued at some US$5.8 million, while shrimp totaled 218,800 lbs. valued at US$1.1 million. Of the total shrimp exports, farmed shrimp constituted only 9%.

Cooperatives are processing most of the cultured shrimp. During the April 1987-March 1988 season they exported 23,713 lbs. of farmed shrimp out of total shrimp exports of 284,250 lbs. The Placencia cooperative presently is best located to do processing for many of the shrimp farms. The Placencia cooperative has assisted with processing for some of the farms, although they will need to increase their ice production capacity and their capability to process relatively large volumes in short time periods to meet present and future needs. Recent records of the Belizean Fishermen Cooperative Association indicated that Northern Coop took care of all the farmed shrimp processing in 1988.

Cooperatives are very keen to process and export more cultured shrimp despite the relatively small sizes. However, for the time being they are reluctant to make any investment purely for shrimp (e.g., an IQF machine) as they first want to make sure that an increase in production is forthcoming. This would have to come from culture operation, given the limits to further exploiting wild stocks. The same reason was given for the limited interest in producing value-added shrimp (based) products. Without sufficient advance warning of the dates of harvest and approximate volume of shrimp to be processed, cooperatives cannot prepare to meet the demand.

2.3 Reasons Why the Shrimp Mariculture Industry in Belize Has Not Developed as Rapidly as First Expected

The initial investment cost of developing shrimp mariculture in Belize appears to have been, and continues to be, the single most significant impediment to rapid development of the industry in Belize. The capital costs for establishing a shrimp farm in Belize have been estimated by entrepreneurs at US$4,000 to US$8,000 per acre, a range which is double the cost for similar enterprises in other Central American countries and the U.S.

The reason for such elevated capital costs can largely be traced to the isolation of production sites from existing infrastructure within Belize, and the need (real or perceived) for importing a majority of materials and equipment. Entrepreneurs in most cases are generating their own power because they are beyond the reach of the national electrical distribution system. They are also obliged to keep adequate

supplies of spare parts on site because of long delays experienced in the import of replacements. Finally, most shrimp farms in Belize have short- to medium-term plans to establish relatively large-scale operations in order to realize economies of scale for operations such as on-site hatcheries, power generation and pumping stations, and freezing and/or processing, since such services are not otherwise available.

The net result of elevated capital costs is a much longer payback period for realizing a return on the investment, and a consequently greater risk and lower return. Projections for shrimp farms elsewhere in Central America and in the U.S. indicate that, once the farm is fully operational, cumulative profits will generally exceed initial investment in periods ranging from less than two years to approximately three years. Projections done by entrepreneurs in Belize reflect a substantially longer average payback.

Perhaps more importantly, the plans for establishment of shrimp mariculture in Belize developed by each entrepreneur suggest longer construction phases, only partly due to larger scale of operations, than other Central American counterparts. Interruptions in construction caused by weather, unexpected site conditions, and financial shortfalls become understandably more frequent as time passes.

Within this framework, the following obstacles have been encountered by entrepreneurs in Belize:

General

1) **Funding was mentioned by almost all producers as a major constraint to aquacultural efforts in the country.** This is certainly no surprise and is no different from what has been seen in most countries when this industry first was developed. Commercial lending institutions do not deal in risk or venture capital operations. A successful track record, on-site, is necessary to whet their interest. Therefore, private investment with risk capital is not likely to change as the stepping stone for these ventures.

   With higher start-up costs to begin with, however, most farms have tried an incremental approach to construction. This further delays the realization of a return on the investment because actual production costs become higher with the loss of economies of scale, and initial profits are reinvested in additional construction.

2) **Initially there were few to no service industries serving the fledgling shrimp mariculture industry, and each farm necessarily had to take on all areas of farm construction individually.** This situation has changed very little, although once a threshold level of shrimp production is reached in the country, future entrepreneurs will be able to depend upon expansion of services, which will be much easier than initiating services.

Construction

3) In many cases, **pond construction costs have been higher than projected** due to the necessity of removing silt or sand and replacement with clay. Any new pond construction should include good soils information within the initial feasibility study. Additionally, **contractors have not always met pond construction schedules and quality requirements.**

9'

4) **Weather is critical to pond and water delivery system construction, and efforts must be suspended during the rainy season** -- usually the months of July through January or February (see Table 2). All but the newest farm (which just began soil work during this dry season) reported uncompleted work during the preceding "dry months." Often this uncompleted work was due to equipment breakdown, so perhaps old equipment should be listed as a separate constraint.

TABLE 2

AVERAGE ENVIRONMENTAL CONDITIONS -- BELIZE CITY

	Average daily temperature range (degrees F.)	Relative humidity (Percent)	Average monthly rainfall (inches)
January	81 - 67	92 - 89	5.4
February	82 - 69	91 - 87	2.4
March	84 - 71	90 - 87	1.5
April	86 - 74	91 - 87	2.2
May	87 - 75	91 - 87	4.3
June	87 - 75	93 - 87	7.7
July	87 - 75	93 - 86	6.4
August	88 - 75	92 - 87	6.7
September	87 - 74	94 - 87	9.6
October	86 - 72	94 - 88	12.4
November	83 - 68	94 - 91	8.9
December	81 - 68	93 - 90	7.3

5) **Belize lies within the hurricane belt.** Provisions must be made when constructing ponds to withstand periodically severe weather conditions, or to repair installations after the fact.

Operations

6) **Low nutrient levels in Belizean waters require high levels of fertilizer** in ponds to encourage planktonic and other macroorganisms' growth which is necessary for cover and supplemental food sources for the pond-reared shrimp. As demonstrated in section 4, fertilizer is not so expensive an input that it severely reduces mariculture profitability. However, by not utilizing fertilizer, farmers risk significantly lower yields which could eliminate profitability. Therefore, provisions should be made in all operating plans for a sufficient amount of fertilizer.

7 **Extremes in salinity during the rainy season inhibit growth rates** and every effort should be made during site selection to insure that adequate oceanic sea water is available to maintain salinity levels within best growth ranges.

8) **There remains a serious lack of shrimp processing equipment within the country.** Ice, processing, and freezing facilities are planned for each individual farm, but at present none are adequate. Harvests have been delayed in the past while processing arrangements were made or adjusted.

9) **Many ponds in Belize have had stocking delayed while waiting for delivery of seed.** Probably the highest priority need for successful farming of shrimp is a completely dependable supply of healthy seed stock. The best designed and engineered system anywhere in the world will fail without this area under 100% positive control. Additionally, a tried and proven species should be targeted, since poor growth can also bankrupt any operation. Government should not restrict procurement of seed, since no single source can guarantee perfect availability.

3.0 GENERALIZED "NEEDS" OF SHRIMP FARMING WITH REFERENCE TO BELIZE

With all culture methods, certain parameters need to be met prior to attempting to build a farm (Appendix A). There are very few, if any, "perfect" sites, so the would-be farmer has to compromise somewhat. Priority must be given to some items, such as water quality, where no compromise is possible.

3.1 Design of Facility

There will be no attempt to describe one design since all will be site specific; however, a general list of components must be considered. There cannot be a consensus on the optimum production system. Each and every farm must pioneer a bit on its own to adapt to its precise growing conditions. However, some sharing of data between similar sites could potentially save time and money. There is sufficient demand that Belizean producers are not competing for a limited market, and therefore have nothing to lose with other farms' success. In fact, by cooperating Belize is more likely to create a good reputation on the international market.

3.1.1 Water

Probably the most important consideration in design layout of a shrimp farming facility is the water delivery/return system. An estuary (or open sea) system deep enough to maintain water supply (if needed) throughout a complete tidal change should be selected. The estuary should be close enough to the pond site(s) to preclude construction of any long and expensive delivery channel or canal. All successful shrimp farms have good and immediate accessibility to water in the event that a partial water change becomes necessary for some reason. In some cases, this accessibility can be the estuary itself. In others a feed canal or settling/storage ponds may be deemed the better approach.

Water delivery canals should be adjacent to each pond with corresponding water control structures available for each. A water return canal usually traverses the opposite side of the ponds and can incorporate a catch basin for shrimp capture during pond draining. High volume, low lift pumps with a capacity of 20,000 gpm or greater are necessary for each 50-75 acres.

3.1.2 Water Control Structures

Intake structures usually are screened to as small as 1/8" screening in order to remove as many predators as possible. This fine pond-site screening must be preceded with larger mesh filtration, usually around the primary intake and again before entering the water feed canal or reservoir. Filtration usually is done in several steps and with decreasing filter size. Intake water, if allowed to flow down into a pond over a series of baffles or steps, can be oxygenated by this process; so if elevation allows for this "energy-free" dissolved oxygen generation, the advantage should be used.

Outlet structures are commonly designed with two sets of dam boards parallel to each other so that water exchange can be made from the surface or the bottom of the pond. With this capability, freshwater buildup on the surface (from rain) can be removed before large salinity changes can occur and/or poor quality, oxygen-deprived bottom water (due to excess feeding, fecal buildup, and other action which might

increase biological oxygen demand) can be removed before animal stress might occur. Drain structures are usually incorporated into a catch basin system for animal capture at harvest.

In Belize farms, water supply and control structures have followed this general description. However, at least one farm is lifting water some twenty-two to twenty-four feet -- much higher than the six to eight feet which is common in most successful shrimp farming areas.

3.1.3 Ponds

Ponds can be of any size. However, for efficiency of management (water quality, feeding, and harvest), most successful operations have ponds ranging from ten to fifty acres. Adjacent ponds are often of different size due to differences in land elevation, surrounding estuaries, or mangrove forests. These size differences are insignificant as long as water intake and discharge systems are compatible.

Pond levees are constructed best by bulldozer. The bulldozer pushes soil into a berm and then compacts it. This compaction is a necessary construction step, and levees built without adequate compaction will soon erode. Levees with at least a 3:1 slope are best to prevent erosion, although often levees between ponds which carry little surface load may be somewhat less. A major load carrying levee (for instance, one used by trucks to carry feed and fertilizer to ponds and harvested shrimp from ponds) should be built with a slope greater than 3:1 and in these cases 6:1 is not uncommon.

Pond bottoms should slope slightly toward the drainage/harvest structure if possible. If the pond is very large and the topography very flat, often a borrow canal is dug around the inside of the levee (actually the levee is constructed from the earth removed from this borrow) and constructed such that it will drain toward and into the harvest structure.

Regarding soil conditions in the coastal areas of Belize, there is certainly adequate clay in these areas to build pond levees, but in some instances both surface organic silt and/or sand have had to be removed and replaced by clay, increasing construction costs. At least one report indicated a low soil pH and recommended lining pond bottoms to neutralize their audity. Seawater acts as a natural buffering agent, however, and usually requires no additional treatment. Pond bottom surfaces usually approach neutrality reasonably soon after seawater is added, even though an acid soil condition may remain subsurface. In more serious cases of low pH, agricultural grade lime must be added. One Belizean shrimp study referenced in Appendix B has calculated that 600 lbs./acre/year would be adequate. The cost of agricultural grade lime is approximately BZ$0.12/lb.

3.1.4 Nursery Systems

Over a period of years, shrimp culturists have learned that a nursery period is well worth utilizing in a shrimp farming venture. Where early pond stocking was done with postlarval shrimp, final harvest would often be only 15-20%. With juvenile stocking from nursery ponds, it is common to harvest 80-90%. The nursery system entails placing postlarvae in small ponds adjacent to the growout pond(s) and feeding daily at a high body weight percentage for approximately thirty to forty days. Samples are then taken for size and number, and growout ponds are stocked accordingly. A nursery pond is sometimes constructed within one corner of a growout pond.

13

With this type design, each growout pond has its own nursery pond. Where space allows, a common nursery pond is sometimes strategically placed to serve two to four growout ponds. In this case, the nursery pond is larger to accommodate greater numbers of postlarval shrimp.

Some farms with ponds of five acres or less do not utilize the nursery concept, stocking directly from hatchery to growout areas. When this is done, heavier stocking rates should be used. This stocking rate will depend on which culture method is to be used or what harvest poundage is desired. Most aquaculturists have found survival rates from hatchery to 1 gram juveniles to be about 50% and from 1 gram to 19 or 20 gram harvest size to be 85% and above. Pond management can definitely be more precise if juvenile shrimp are stocked from a nursery pond simply because the pond manager knows exactly what is in the growout pond at that time.

3.1.5 Product Recovery

At harvest time, catch basins designed within the water outlet system are either screened completely to retain all shrimp during pond draining or net bags are incorporated to retain shrimp during water discharge from the pond. In the former case, a large, basket-type net is continually lowered into the catch basin and the shrimp which have been gathered there are bailed out and loaded into tanks mounted on trucks. In the case of net bag capture, shrimp are usually placed into boxes and then loaded onto flatbed trucks for delivery to the processing plant.

3.1.6 Electrical Plant

None of the farms visited had utility-produced electrical power available. Regardless, however, of the reliability of any local power company that may become established, it is a must to have a diesel-powered electrical generator set up to automatically come on during any power failure. If hatchery, nursery, or growout systems are at all dependent on electrical power for maintenance of water quality (and all are) and/or frozen shrimp are being held in freezer inventory during power shortage or outage, the potential loss due to such a catastrophe easily justifies the expense of having this backup system.

3.1.7 Predation

During pond design and layout, security should be thoughtfully considered since human predation has been seen as one of the major causes of shrimp loss in many shrimp farms around the world. Guard houses should circle the pond areas particularly from the estuary approaches. Water ingress seems to be the preferred method of human poachers. This is not surprising when one realizes that workers' houses, hatchery, and processing buildings are generally on the upland side of any shrimp farm.

Water intake areas should be screened to prevent entry of marine predators which will compete with shrimp for feed and may consume the shrimp themselves. As for birds and small animals such as raccoons, there is little one can do short of killing the animals unless workers are in the areas during the day and see predation occurring. Firecrackers and bird repellents will frighten at the moment but don't have long-term action and do very little to encourage birds to stay away.

3.2 Seed Production

3.2.1 Hatchery

Without postlarval shrimp, or seed, to stock ponds, the best built pond system would be worthless. Lack of adequate seed stock in Belize has been a constraint on successful operations to date, and in fact at the time of writing this report, there are empty ponds within the country awaiting seed stock from somewhere.

Seed stock must be available with no exception. Growers must have guaranteed availability of postlarval shrimp at all times. If this means each farm has to have a hatchery, then so be it. Two hatcheries already exist in Belize, although neither was being operated during the preparation of this report. If these hatcheries become operational, they can be capable of handling the needs of the entire Belizean shrimp farming industry, based on pond acres completed and under construction. One farm presently under construction (nearly 120 acres) plans to get seed stock from an associate farm in Texas.

Hatcheries should look carefully at rearing Penaeus vannamei. This is a non-indigenous species from the Pacific side of Central and South America. It is easily cultured, tolerant of temperature and salinity changes, fast growing, and gets good feed conversion. In short, it has been the species selected by most serious shrimp farming operators in this hemisphere because it has outproduced other species tested to date. The current advantages of P. vannamei appear obvious. Research has been done on the species in the region, the growth rate is favorable, and the produced sizes are very much in line with those currently demanded by major markets.

Government must not restrict farmers' access to any postlarvae source, even in the interest of promoting local development, for such restrictions could irreparably cost a farmer time and money if the favored source were unable to produce a quality product in a timely manner.

3.2.2 Wild Stock

In the natural condition, penaeid shrimp spawn in deeper offshore waters; eggs and larvae are carried inshore by tides and currents; postlarvae and juveniles develop within protected estuaries and bays; and young adults migrate back to deeper water to fully mature, spawn, and begin the cycle again. This entire process takes no more than one year. Only one species follows this yearly cycle within coastal waters of Belize. This is Penaeus schmitti. The life cycle is dependent on hydrological and meteorological conditions and, because of the general lack of organic matter in the estuarine systems in Belize, there is little natural shrimp production.

3.3 Feed

Feed is generally the single most expensive operating cost item, so every effort should be made to control this cost. One way this can be done is by producing feed on-site and in bulk rather than purchasing feed mill prepared rations in 100 lb. bags. None of the farms which are currently producing penaeid shrimp are feeding a ration formulated on site. Producers have not been satisfied with growth rates they are experiencing and all seem to have changed feed labels one or more times, eventually settling on the more expensive imported feeds: "President" from Taiwan, Dupont, Rangen, and Zeigler from the U.S. One farm hopes to soon import Guatemalan feed at

a substantial savings. There is a feed mill located in Belize City which could probably mix a shrimp feed if necessary raw materials were available, although additional investment may be required to guarantee a finely ground, well-bonded pellet. (Table 3).

TABLE 3

TYPICAL PENAEID FEED FORMULATION

39%	Corn
25%	Flour
20%	Crustacean Meal
10%	Fish Meal
5%	Rice Polishings
1%	Vitamins and Minerals

Since feed price and quality are essential to viable shrimp farming, government must not restrict farmers' access to preferred sources. If a quality feed is produced in Belize at reasonable cost, producers will naturally choose it over the alternatives.

3.4 Processing

If processing is not done at the farm, it is necessary to ice the shrimp at pond site to ensure quality. Most farm-raised shrimp from Central American countries are exported to the United States where they may be further processed as peeled, peeled and deveined, butterflied, cooked, IQF's, or any combination of these additional steps.

Pond-raised shrimp in Belize have generally been headed, packed on ice and trucked to one of two fishery cooperative facilities for processing. Processing usually includes washing, grading, packing, freezing, and glazing. At present most farms are constructing or have plans to construct processing facilities on site. Some plan initially to process only as far as heading and chilling, leaving grading, packing, and freezing for the cooperatives. It should be noted that, contrary to earlier reports, adequate processing facilities are not available on a daily basis at this time in Belize. Besides handling and freezing limitations per day, additional restrictions such as lack of ice (cooperatives' fishermen take priority on limited ice supply) and product handling (lobster take priority over shrimp or fish) can cause scheduling problems at harvest time.

All grading in Belize is presently done by hand count, sizes usually separated visually and by hand. When large harvests become routine, it will be necessary to machine grade the shrimp tails not only for speed and efficiency, but also to maintain quality control necessary for successful marketing.

After grading, shrimp are hand-packed into 5 lb., wax-impregnated cardboard boxes, weights are checked for tolerance, and enough water is added to glaze the bottom of the shrimp when frozen. The boxes are then loaded onto wire racks or shelves and frozen either in blast or plate freezers. When freezing is complete, boxes are removed, opened, and additional water is added for surface glaze. The boxes are closed, turned upside down (so that newly added water will freeze over the surface of

the shrimp) and replaced either in the original freezer or into the storage freezer. Initial freezing by blast freezer is generally about -40 degrees F. while storage can be at 0 to -20 degrees F.

Farmed shrimp provides producers and processors with certain advantages over wild caught shrimp which need to be sustained throughout the production and marketing process in order to increase profitability. These advantages consist of freshness (they can be iced and/or frozen the minute they leave the water) and processing possibilities. This refers to variety of product forms. Super fresh and undamaged shrimp can be produced into whole, whole-split, or chitin. For this to be possible, a few prerequisites need to be in place:

- o processing/storage facilities on the farm, or
- o farms need to be close to processing facilities, and
- o appropriate means of refrigerated transport, and
- o appropriate facilities in the processing plants.

For farms of the size currently in operation in Belize, it appears almost impossible to justify an investment in a processing plant, taking care of all the quality control and value added requirements. The erection of shacks for processing (deheading and peeling) should be avoided at all costs, as this will have immediate repercussions on quality and consequently on the entire sector's reputation abroad. This will soon be followed by decreasing offer prices and less demand, particularly if the major markets are the tourist industry in CARICOM countries and the USA.

A disadvantage facing a number of farms is the distance to the established processing plants. The lack of high quality transport infrastructure makes their position even more precarious. They are almost obliged to put shrimp on ice on site, as they will otherwise have to contend with serious losses of quality.

3.5 Marketing

Four potential markets can be distinguished: CARICOM, USA/Canada, local tourist industry, and Europe.

The CARICOM market potential for shrimp is strongly tied to the tourist industry. The particular markets are Jamaica, Grenada, Barbados, and St. Lucia. Vessel connections are relatively low in frequency. In view of trade agreements between CARICOM countries, certain products (e.g., beef and beans) have increased in price because of protectionist rules. This has increased cost of living and causes dissatisfaction among the population of the various countries. Therefore, a consistent policy on tariffs by the participating countries cannot be taken for granted on the medium- or long-term. Other producing countries may try to enter this relatively lucrative market, e.g., China and Ecuador. Size preference is for 21-25 count per pound through 61-70, with emphasis on 25-33s. It should be kept in mind that Guyana also has a substantial shrimp production which, at any given point, it might try to market within CARICOM.

In addition to potential competition, the limiting factors of the CARICOM market are:

- o it is relatively small (estimated at 1.5 million lbs.); and
- o it is seasonal (November-April with peaks in January-February).

The USA appears to be a significant market outlet for Belizean shrimp. Preliminary discussions with U.S. importers indicate fair interest in Belizean white shrimp. In their opinion, Belizean shrimp falls in the same category as Ecuadorian white, which is positive because of the good reputation, fair price levels, good demand, and utilization by the majority of the processors/outlets. Price is the major market determinant.

Most shrimp, from whatever source, enters the U.S. market duty free. Only products which have been classified as "prepared or preserved" would have a 5% duty. Belize could receive a duty exemption under the Caribbean Basin Initiative (CBI) for these value-added products, but under present conditions it has not been recommended that Belize attempt to produce these products.

A good demand is anticipated from reprocessors, particularly in the New Orleans area. In order to take maximum advantage of this market opportunity, grading close sizing has to be done. Furthermore, these processors are only interested in container loads (40,000 lbs.).

Because of favorable airline rates, the possibility of fresh or fresh-frozen shrimp exports by air to the USA should be pursued, particularly during the USA-Mexico Gulf off-season. Unfortunately, this coincides with the peak season in the CARICOM markets.

Although the Belizean tourist industry shows substantial potential, it appears that the government has chosen a controlled and cautious growth. Therefore, the potential of the local tourist market for shrimp will remain relatively small.

Transport costs make any exports to the European market impossible, even for head-on shrimp. In addition to the high costs, the trip takes between four to six weeks, which is too long. Only when the culture industry would be able to produce very large volumes may this option become viable, as charters can be considered.

Of these four markets, the U.S. should be considered the primary market for planning purposes. It is sufficiently large and accessible to warrant investment to serve it. Once production has begun, farmers may take advantage of opportunities to enter other markets as they arise.

3.5.1 Transport

Two liners frequent Belize. They appear to have plenty of space available, since more goods are presently shipped into rather than out of Belize, and the liners are keen to accommodate any request by seafood exporters in order to improve their business. These two liners frequent most Caribbean islands. Air transport is to the USA only, with destinations Miami, New Orleans, and Houston. The rates are very favorable (US$0.14 to 0.22 per lb.), depending on airline and volume.

3.5.2 Market Channels

Market channels are straightforward and the use of middlemen on the national scene in Belize does not appear to exist. Exports to the U.S. are also direct, although no effort is made to sell to lower level wholesalers or restaurant/catering. Cooperatives appear to favor longstanding trade contacts. Price and easy movement of the goods are the basic criteria.

4 0 ECONOMICS OF SHRIMP PRODUCTION IN BELIZE

The profitability of shrimp mariculture production in Belize will largely dictate the ultimate level of total production, since investors will not be inclined to put marginal sites into production where costs begin to approach or exceed revenue. It has been noted earlier that present investors in Belize are already operating under less profitable conditions than may be experienced in other countries, due to lack of infrastructure such as roads and public utilities. It is therefore recommended that government should work to improve infrastructure in the areas which are appropriate for shrimp mariculture. The shrimp farming entrepreneurs are already making some contributions to local infrastructure, but they cannot efficiently establish a nationally linked system without the collaboration of government. It may be said that Belize is becoming a well-suited country for shrimp mariculture, and if the existing pioneering entrepreneurs realize their dream to establish a solid foundation, then other entrepreneurs will be able to enter the sector much more easily, with lower initial investment and lower risks.

Given the large capital investment required for building shrimp ponds and establishing operations, in addition to ancillary services which are not presently available, it is important that investors be able to plan over the long term what their operating conditions will be, including physical parameters, economic circumstances, and policy influences.

Government policy and programs can significantly affect the profitability of shrimp farms. Government may also influence the way shrimp farmers operate, through regulations and/or provision of benefits or services. Since government policies can affect the long-term (ten years) potential of the shrimp industry, the purpose of this section is to highlight the structure of the industry at present, to discuss its future potential, and to demonstrate the likely effects of potential government policies so the advantages and costs of each option to the country as a whole may be weighted.

In principal, any private venture not critical to national welfare should be able to make it on its own. In view of special circumstances the shrimp industry has to deal with, the government may wish to consider granting certain privileges, but only during a particular phase and for a limited time span. Therefore, it is recommended that the government review its policy on the granting of privileges, subsidies, and exemptions. Only higher outputs at lower cost will enable producers/processors to justify increased investments.

4.1 Characteristics of Production which Affect Financial and Economic Feasibility

As discussed in Section 2.1, there are a number of different accepted culture methods for growing shrimp. The relative feasibility and profitability of each method depends on the quality and cost of available inputs. The fact that the farms in Belize presently range from semi-intensive to intensive culture indicates that changes in factor prices and quality will affect different farms quite differently.

For most of their inputs, shrimp farmers in Belize presently depend on imports. Postlarvae and feeds are imported, as well as most of the equipment. Also, in terms of labor, it must be noted that experts are mainly foreigners, and manual laborers are

often nationals from neighboring countries. It can only be a gradual process, but the ultimate goal -- both for producers who will find their costs reduced, and for government which seeks national development -- is to increase the local contribution to the entire production process.

For purposes of analysis, shrimp farming may be subdivided into four distinct operations, each relatively independent of the other. These operations could be undertaken, if desired, at different sites. The first two operations are seed production (hatchery) and feed production. These two operations are essential inputs to the third operation -- growout. Once growout has been accomplished, the final operation is processing.

4.1.1 Seed Production (Hatchery)/Postlarvae Supply

The only way to ensure postlarvae supply is to produce postlarvae locally. Seedstock has no substitute. The cost of producing postlarvae in Belize should be lower than the cost of importing postlarvae from outside the country, since conditions are adequate and shipping and associated injury and mortality are among the greatest costs of postlarvae acquisition. However, an initial investment will have to be made in facilities which can produce with reasonable economies of scale.

Even though it is recommended that postlarvae be supplied domestically, government should not use import restrictions to promote this development, since this fragile industry could be severely damaged in the meantime.

Until a successful hatchery is operating in Belize, one cost-effective method of obtaining PLs is the importation of nauplii and subsequent growout on site to PL size. Transport costs for nauplii are significantly lower than those for the same number of PLs. In addition, mortality can be substantially reduced during the adaptation and transfer process from hatchery to nursery/growout pond. The cost of nauplii was about US$3.50/1,000 FOB Panama in April 1989.

The landed cost of P. vannamei postlarvae in Belize is comparatively high, and the supply is a very delicate matter. P. vannamei postlarvae have been purchased at a cost of US$7.00/1000 FOB Panama and landed in Belize at US$7.85/1000 CIF. Import duties have been reported as high as US$3.30, for a total of US$11.15/1000 total cost of procurement. Hatcheries in Belize thus would be able to have their costs 12% greater than in Panama, for the landed price to be the same, even if all duties were lifted.

Demand for P. vannamei postlarvae is expected to triple over the next five years (overall increase in acreage and density all over Latin America) and hatchery production will be hard pressed to match demand. Suppliers may charge prices which are considerably more than their costs. Also, non-market factors (possibly including individual supply agreements between hatcheries and farms) may make importation of postlarvae impossible.

4.1.2 Feed Production

Local feedmills may be encouraged to engage in joint venture agreements with foreign enterprises to produce high quality feeds. In view of the poor feed quality in neighboring countries, this could be a substantial source of foreign revenue also. Feed quality is a major determinant of growth rate, and hence ultimate cost of pro-

duction. There have been instances where feed suppliers have changed their feed formulation, and shrimp farmers have only discovered the consequences after loss of time and money when shrimp have not maintained estimated growth rates.

The local feedmill would have to invest in some additional equipment to ensure that feeds would be ground finely enough to ensure binding of ingredients -- otherwise, rapid dissolution of pellets would result in more feed at the bottom of the pond than consumed by the shrimp. Some feed ingredients, such as fish meal, are not likely to be available in adequate quantities for appropriate formulations. Nonetheless, importing the raw materials would ultimately be less of a drain on foreign exchange resources, and having feed produced in-country gives important control on quality. The primary requirement for success of a local feedmill will be its ability to demonstrate that it can meet shrimp farmers' requirements, so the farmers will not be inclined to shop elsewhere to preserve their important investment. Once farmers have confidence in local product, there should be adequate demand for the feedmill to obtain necessary economies of scale. In the meantime, government should not restrict farmers procurement of feed.

Presently shrimp farmers have basically two options for obtaining feed. Feed imported from other Central American countries is cheap but of very poor quality. Imported feeds from Taiwan and USA are good but extremely expensive. In either case, feed cost could comprise some 30% of the total production costs when using the semi-intensive production system.

4.1.3 Growout Operation

The growout operation is the activity which requires the greatest amount of capital and entails the greatest risk. Venture capital is the obvious source of funding for this operation. The profitability of growout is dependent on the behavior of living organisms in a complex natural environment which can be modified but not completely controlled by the producer. Growth rates, mortality, and feed conversion rates are the primary determinants of profitability.

These rates may be roughly estimated based on results at other sites, but actual results may vary due to variables in Belizean conditions which have not been analyzed. To date, shrimp farms in Belize have operated under a wide variety of operating procedures (including pond design, stocking density, and feeds), and results appear to have been very inconsistent. Unfortunately, with only a minimal amount of poor quality data available, it is not possible to account for all specific conditions and events which are likely to affect shrimp production in Belize in the future.

4.1.4 Processing

Shrimp processing is being successfully undertaken in Belize by several cooperatives, although some have only dealt with the wild caught product. At present the cooperatives accept shrimp which has already been headed, although this service could theoretically be provided also, if shrimp is delivered rapidly after harvest and with sufficient advance notice to the processor so that laborers are available. Processing is a low risk operation: so long as hygiene and quality control procedures are followed and refrigeration equipment is kept in good working order, yields from whole shrimp to packaged, ready-to-ship shrimp are quite predictable. The primary inconvenience and lack of cost efficiency in the processing activity results from unpredictable and/or inconsistent supply of shrimp ready for packaging,

which can alternately idle and overwork a facility. Similarly, incompatible shipping schedules may require additional storage of product which is otherwise ready for sale.

Transportation to the processing site can be a problem for the shrimp farmer. To ensure quality, the shrimp must be kept on ice from harvest through processing. Ice represents an additional cost to the farmer, but must be available in sufficient quantity at the farm site to ensure optimum quality of the final product.

4.2 Comparison of Shrimp Mariculture to Other Economic Activities

Shrimp mariculture is much like agriculture in the sense that the aquaculturist is adding various inputs within a controlled environment to promote the growth of a living organism for its subsequent harvest. The careful manipulation of inputs and the environment over the life cycle of the organism differentiates aquaculture from capture fisheries. Capture fishermen begin their investment at harvest time, relying on natural production. The fact that aquaculture relies on the response of living organisms, entailing complex biological processes, differentiates aquaculture from industrial production of other commodities which can be produced with little risk that yield projections will prove inaccurate.

The unique characteristics of shrimp mariculture should be considered every time policies affecting the activity are defined. The government of Belize has already acknowledged that shrimp mariculture is not harvesting a natural (or public) resource by removing the 5% export tax on shrimp which is cultivated. Belize also has legislation which dictates that a "fair amount" of shrimp must be sold on the local market. This law was also originally intended to compensate the public for use of their resource by capture fishermen and should not be applied to shrimp culturists.

The government policy of development concessions is designed to aid the introduction of all new productive activities which can benefit the country. These concessions are granted over a finite time period. It is assumed that the time period defined will be sufficient for establishing a viable productive activity. It is obviously not desirable that government should subsidize activities which are not economically viable, unless other policy objectives are being served. However, it may be worthwhile to reevaluate the development time frame for such complex activities as shrimp mariculture. This reevaluation will require that government officials have a good understanding of shrimp mariculture in general and the specific proposals of beneficiary mariculturists in particular. This understanding may be gained by improving the services of the Aquaculture Unit, as discussed elsewhere in this report.

Since shrimp mariculture can take a rather long time to become established, one of the most important contributions government can make is to define policies as early as possible and be consistent in their applications. It is extremely difficult for investors to plan their activities without knowing what conditions they may be working under in the future.

4.3 Derivation of Investment Costs

The estimate of average investment costs in Belize was derived principally from figures projected for Belize from four different sources, including producers and potential investors. One of these sources did not provide any indication of the break-out of

different cost elements. Another source supplied figures regarding value of assets rather than actual costs incurred. Two sources presented future projections only.

Cost elements from the estimates provided could be roughly broken into three categories: 1) earthmoving and pond construction; 2) buildings; and 3) equipment. When each cost component is calculated as a percent of total expenditure on these three items, the results for Belize correlate with estimates projected for other countries, namely, earthmoving and pond construction comprised 48-79% (average 61%), buildings comprised 11-30% (average 17%) and equipment comprised 9-31% (average 20%). Engineering services have usually been estimated at approximately 6% of construction costs, although this expense was not included in all estimates provided by the various sources.

It was not possible to evaluate all of the assumptions which form the basis for the financial projections provided to the team, nor the accuracy of figures provided on construction already undertaken. It is believed that in most cases, more earthmoving has been (and may be) required than in other countries, particularly in cases where other countries may simply convert existing salt ponds to shrimp ponds rather than building a pond from level ground. For the farms which have opted to import equipment and labor for earthmoving, it is certain that the cost per unit of earth moved is higher than in other countries.

Elevated building costs appear to be due to the relative isolation of shrimp farm sites from infrastructure and needed materials, although a desire for larger facilities and higher quality construction may also have been factored in.

Elevated equipment costs appear to reflect the higher costs of even the most basic equipment such as trucks. Many items which the Belizean sources propose to import are treated as local inputs in other Central American countries. All farms in Belize show a tendency to stock a greater number of spare parts due to the inability to procure them in a timely fashion.

Each source was projecting a different size total operation, and different stocking densities of shrimp. Only one source clearly compared the economies of scale that would be realized from spreading some costs over two different sizes of operations. This source determined that investment costs per acre could be reduced by two-thirds if the area under production were increased from 100 to 500 acres. However, when the four sources' figures were evaluated, there was no correlation found between total cost per acre and either total farm size or proposed stocking density. Nonetheless, it is reasonable to assume that as farm size increases, building and equipment costs per acre will decline, since management and equipment could be shared rather than replicated in many cases. If investment costs were reduced by two-thirds when farm size increases to 500 acres, then return on investment could be in excess of 12%.

Two hypothetical farm types are presented here which represent a synthesis of available data from a number of farms in Belize.

The first farm is a semi-intensive model, much like many of the farms presently under construction or beginning operation in Belize. The second farm is a more extensive model which could be an appropriate satellite to the first farm, relying on the first farm for specialized inputs and technical assistance.

For ease of comparison, both hypothetical farms have 100 acres of ponds under production. However, in actual practice the more intensive farm would probably be somewhat larger, to accommodate economies of scale, while the more extensive farm could be even smaller, to reduce overall management complexity.

4.4 Impact of Economic and Biological Variables on Profitability of Shrimp Mariculture

Since the available data on potential yields for shrimp mariculture in Belize is inadequate for performing any significant cost analysis, assumptions are based on yields from outside the country under similar conditions.

Since the growout operation is the central activity, the sensitivity analysis will focus on the variables which will affect its viability. Prices for postlarvae, feed, and processing are set at levels presently experienced in Belize. These prices may be reduced if local production is initiated and/or reaches a more economic scale. Sale price estimates are FOB Belize, as transport costs are not included.

The profit margin on these hypothetical farms is quite narrow, because very conservative estimates have been used to reflect actual conditions at present. If RDA recommendations are implemented, over the long term operations will become more profitable. Once infrastructure is established, both initial investment and annual maintenance costs are expected to decrease significantly. However, it will require a reasonably long period of time to realize these recommendations. In the meantime, it is useful to note that in spite of all constraints, investors should be able to keep their operating costs below sale prices.

The slim profit margin for these two farms indicates the delicate balance that managers must maintain in order to realize any return on their investment. Multiple factors influence the actual returns that may be experienced. The following paragraphs highlight the impact of the most important factors.

Survival Rate: In reviewing pro forma economic analyses or financial projections for shrimp farms, it is common to see a wide range (from 40% to 90%) in the estimates of survival rates, even among farms with nearly identical growing conditions, farm design, and production plans. Mortality usually ranges around 50% from hatchery to nursery ponds (also called juvenile ponds) and 85-90% in the growout pond. These figures are sometimes combined and other times viewed separately, which could explain the apparent discrepancies. Other times, quality of PLs and the conditions under which they arrive at the growout ponds (from next door or traveling internationally), may affect initial mortality.

Ponds must be stocked so that an appropriate number of animals do survive. Regardless of the mortality rate, it is imperative to have an approximate idea of how many shrimp are in a given pond in order to maximize growth efficiency and regulate feeding.

For the semi-intensive farm, a 10% change in the mortality rate of PLs (or procurement price) results in a 2% or US$0.07 change in production costs per pound tails. For the extensive farm (which is assumed to have a better survival rate already), the effect on production costs is 1.7% or US$0.06.

Average Semi-Intensive Farm

Site Characteristics

Total Pond Acres	100		
Annual Harvest Wt. (lbs.)	299,559	Annual Wt. of Tails (lbs.):	179,735
Total Initial Investment	$700,000	Investment per acre	$7,000
Annual Return on Investment	4.07%	Annual Operating Costs	$690,479

Biological Factors - Uncontrolled Variables

Survival Rate in Growout Ponds	85.00%
Feed Conversion Rate	2.5
Proportion Tail Weight	0.6

Operations - Controlled Technical Variables

Number of Harvests/year	2
# Days Growing Period	160
Stocking Density/acre	40,000

ANNUAL PRODUCTION STATISTICS PER ACRE

Avg. Harvest Weight (grams)	19.98
Shrimp Tail Count/lb.	37.83
Growth Rate - (grams/day)	0.125
Annual Harvest Wt. (lbs.)	2,996
Annual Wt. of Tails (lbs.)	1,797

		TOTAL	Percent Total Costs	Cost Per Pound Tails	
FIXED OPERATING COSTS					
Management Personnel		30,000	4.34%	$0.17	
Materials/Maintenance		28,000	4.06%	$0.16	
Miscellaneous		6,000	0.87%	$0.03	
TOTAL FIXED OPERATING		64,000	9.27%	$0.36	
VARIABLE OPERATING COSTS					
	Unit Price				Quantity
Manual Labor	$8.00/manday	25,600	3.71%	$0.14	10 men for 320 days
Pumping	$1.50/acre/day	48,000	6.95%	$0.27	100 acres for 320 days
Fertilizer	$0.17/lb.	17,000	2.46%	$0.09	1,000 lbs.
Feed	$0.27/lb.	202,202	29.28%	$1.13	748,898 lbs.
Postlarvae	$7.00/1,000	112,000	16.22%	$0.6	16 million (assuming 50% mortality in nursery)
Processing	$0.45/lb. tails	80,881	11.71%	$0.45	179,735 lbs. tails
Maintenance	8.00%	56,000	8.11%	$0.31	$700,000 investment
TOTAL VARIABLE OPERATING		$541,683	78.45%	$3.01	
OPERATING COSTS		$605,683	87.72%	$3.37	
		$84,796	12.28%	$0.47	12.00% interest on operating capital
TOTAL OPERATING COSTS		$690,479		$3.84	
				$4.00	Average Sale Price/lb.
TOTAL REVENUES		$718,942	NET PROFIT		$28,463 per year

26

Average Extensive Farm

Site Characteristics			
Total Pond Acres	100		
Annual Harvest Wt. (lbs.)	158,590	Annual Wt. of Tails (lbs.):	95,154
Total Initial Investment	$400,000	Investment per acre	$4,000
Annual Return on Investment	4.79%	Annual Operating Costs	$361,446

Biological Factors - Uncontrolled Variables	
Survival Rate in Growout Ponds	90.00%
Feed Conversion Rate	2
Proportion Tail Weight	0.6

Operations - Controlled Technical Variables	
Number of Harvests/year	2
# Days Growing Period	160
Stocking Density/acre	20,000

ANNUAL PRODUCTION STATISTICS PER ACRE	
Avg. Harvest Weight (grams)	19.98
Shrimp Tail Count/lb.	37.83
Growth Rate - (grams/day)	0.12
Annual Harvest Wt. (lbs.)	1,586
Annual Wt. of Tails (lbs.)	952

	Unit Price	TOTAL	Percent Total Costs	Cost Per Pound Tails	Quantity
FIXED OPERATING COSTS					
Management Personnel		20,000	5.53%	$0.21	
Materials/Maintenance		16,000	4.43%	$0.17	
Miscellaneous		6,000	1.66%	$0.06	
TOTAL FIXED OPERATING		42,000	11.62%	$0.44	
VARIABLE OPERATING COSTS					
Manual Labor	$8.00/manday	25,600	7.08%	$0.27	10 mandays for 320 days
Pumping	$0.50/acre/day	16,000	4.43%	$0.17	100 acres for 320 days
Fertilizer	$0.17/lb.	17,000	4.70%	$0.18	1,000 lbs.
Feed	$0.27/lb.	85,639	23.69%	$0.90	317,180 lbs.
Postlarvae	$7.00/1000	56,000	15.49%	$0.59	8 million (assuming 50% mortality in nursery)
Processing	$0.45/lb. tails	42,819	11.85%	$0.45	95,154 lbs. tails
Maintenance	8.00%	32,000	8.85%	$0.34	$400,000 investment
TOTAL VARIABLE OPERATING		275,058	76.10%	$2.89	
OPERATING COSTS		317,058	87.72%	$3.33	
		44,388	12.28%	$0.47	12.00% interest on operating capital
TOTAL OPERATING COSTS		$361,446		$3.80	
				$4.00	Average Sale Price/lb.
TOTAL REVENUES		$380,616		**NET PROFIT**	$19,170 per year

27

Individual farmers may wish to adjust expected mortality rates and prices, including any additions to required infrastructure, to see if the importation of nauplii is more cost effective for their particular conditions.

Feed Conversion Ratio: When feed comprises approximately 30% of the operating budget, the feed conversion rate has an important impact on profitability of the enterprise. Within the range of analysis, a 10% decrease in the feed conversion rate can result in a US$0.11 increase (or 3.3%) in the production costs per pound of tails in the semi-intensive farm, or US$0.09 (2.7%) in the extensive farm. The same impacts would be felt for a 10% increase in feed prices.

Proportion Tail Weight: It is generally recognized that 63% is the maximum potential yield of meat on the average shrimp. The 60% figure was conservatively used to reflect probable losses due to routine processing. Additional care may be taken in processing, but it must be recognized that recovering the 3% yield only increases revenue by US$0.12/lb. harvested. This may create an expense above this level, particularly if it becomes an item of dispute with centralized processors.

Growth Rate: The growth rate affects the amount of time that shrimp must be held in the ponds to reach desired size. The RDA estimate assumes there will be 45 days per year (or an average of 22 days after each crop) where the ponds are empty for drying or repairs. A reduction in empty pond time could compensate for slightly slower growth rates. Higher growth rates could permit more frequent harvests, since Belize conditions permit year-round cultivation (although the rainy season may cause additional expenses for additional pumping).

Daily costs in operating a pond with shrimp in it have been estimated, including labor and pumping, at US$230 or US$130 for the semi-intensive and extensive farms, respectively. Combined, these costs represent 10% and 11%, respectively, of the total production costs. (The absolute costs for pumping at the semi-intensive farm are higher, but higher costs of feed offset the percentage.) Harvesting a pond twenty days early could thus theoretically save US$0.05 or US$0.03, respectively, per pound tails. This is very important to know since the relationship between sale prices for different weights and the additional cost for increasing weights may change, and the shrimp farmer will wish to harvest for optimum profit at all times. With the growing importance of aquaculture around the world, world markets appear increasingly interested in sizes 31-40 and 41-50 as this presents the most stable supply, at relatively favorable price levels.

Personnel and Miscellaneous: The chosen method and scale of operations will significantly affect these fixed costs. Competent (and generally expensive) personnel may be able to single-handedly manage large complicated farms, while smaller farms with a greater margin for variance in conditions may be managed by lesser trained individuals or on an intermittent basis. For example, if a farm must maintain a high density and strict harvest schedule, it is much more vulnerable to problems with mortality and slow growth rate than a farm which maintains a lower density and can afford to delay harvest if problems occur.

Many of the investors in Belize have essentially subsidized their fixed operating costs because key managers are working for less than their "market value" elsewhere in the world. This is a clear indication of their dedication to establishing operations in Belize. In addition to "management" functions, some of the expatriate operations in Belize are also able to contribute to maintenance efforts, which again lowers fixed

operating costs, and can significantly improve efficiency under difficult operating conditions where repairmen and spare parts may take a significant amount of time to reach the farm.

The estimated fixed operating costs, combined with routine maintenance, comprise 20-21% of total costs. This is largely due to high investment costs, and the assumption that repair and maintenance of facilities will be proportional to initial construction. As infrastructure in the country expands with the development of shrimp farming and other enterprises in the area, it may be assumed that these costs will diminish somewhat. In the meantime, keeping these costs in check is essential for profitability -- for a 16% to 26% increase in these expenses, all other things being equal, would render these operations unprofitable.

Labor: Many operators in Belize have stated that labor costs in the country are high compared with regional standards. It was found, however, that labor costs for shrimp farms elsewhere in Central America were usually projected in the same range as is common in Belize. Shrimp farm managers must train their workers to perform their tasks appropriately and with consistency. The quality of labor is more important to the success of an operation than the price, within the range suggested. At less than 4% of total costs at the intensive farm, changes in labor costs are in fact negligible, with a 10% increase only increasing total cost per pound of tails by US$0.02 or 4%.

Pumping Costs: Pumping costs are dependent not only on price of fuel, but more importantly on site condition and farm characteristics. Again, where other countries' diesel prices were available, they were found to be reasonably similar to those in Belize. The cost of transport of diesel to the site may decrease with the improvement of roads, and government policy will continue to affect sale prices. However, all farms will have to evaluate their costs based on the distance and height they must pump their fresh and seawater. Then decisions may be made regarding the density of shrimp which can be economically supported and the extent of water exchange. Increased water exchange will improve yields by removing wastes which can stunt growth and/or cause mortality. Additionally, some sites may require pumping to maintain optimum salinity levels, particularly during the rainy season. All farms should maintain pumps, even if they are not constantly used, to ensure that poor water conditions can be improved prior to complete mortality in a pond.

4.5 Estimate of Production and Delivery Costs to U.S. and Major CARICOM Markets Compared to Competing Sources

Once infrastructure costs are brought under control, combined production and delivery costs experienced in Belize by the aquaculture industry are very similar to those experienced by its most likely competitors. As mentioned earlier in this report, initial investment costs for similar installations appear to be significantly higher in Belize, and the estimated maintenance for these installations thus raises the break-even price.

Shipping freight rates for Belize can be as low as US$0.10 per pound of tails shipped. Belize's main competitors are likely to be its Central American neighbors and the U.S. Data projections were obtained for El Salvador, Honduras, Costa Rica (all three funded by USAID in 1987-1988), and a typical Texas farm (private consultant estimate). These projections envisioned break-even prices from grown shrimp to range from US$3.00 to US$4.00 per pound of tails for 30-35 count shrimp (tails), CIF the U.S.

The projections assume frozen, sea freighted product from the Central American countries. U.S. production would also have to be frozen or otherwise preserved except for a very short period in October, because U.S. climate does not permit year-round cultivation. While Belize would be marginally competitive under these conditions, by taking advantage of its proximity to the U.S., inexpensive airfreight rates, and its year-round growing season, Belize should be able to cater to the U.S. fresh market.

More than competing with other sources of shrimp, it will be important for Belize to ensure, insofar as possible, that there will be a market for its own product. On an international scale, Belize will not have a significant effect on commodity prices, nor will it "crowd out" production from other countries. Market prices may fall at some point if there is oversupply, which some have predicted with the increasing establishment of aquaculture operations around the world, but these prices cannot fall below production costs in the long run. Belize will simply be affected by the rise or fall of demand and prices which may be caused by the "big players" in the industry making some breakthrough in cost efficiency (unlikely), or reaching some insurmountable obstacle which contracts production to the point where prices rise in response to limited supply.

It has been emphasized throughout this report that the probability of meeting projected returns can be as important as the level of returns projected. Shrimp farming is vulnerable from the supply side, because PLs can be difficult to procure, and from the demand side, because market demand is relatively unpredictable. The production technology itself is vulnerable to upsets by nature.

Belize can produce within a competitive range. Improving the probability that operations will be increasingly profitable is the best way to attract foreign investors. Three activities the government may wish to support to achieve this end include: a hatchery in the country; development of one or more market niche(s) which may yield higher prices; and continued and increased support to the Aquaculture Unit so that country-specific data and technical assistance will be increasingly available to solve problems.

5.0 ESTIMATE OF LONG-TERM (10 YEARS) POTENTIAL OF THE SHRIMP INDUSTRY IN BELIZE

This report has highlighted many of the obstacles which have slowed the establishment of a shrimp mariculture industry in Belize. Many deficiencies are being remedied by mariculture entrepreneurs themselves, while others are being alleviated by the overall development of the country. GOB undoubtedly can play an increasingly important role in guiding mariculture development to its optimum level.

The next five years may be critical for shrimp mariculture to either flourish in Belize, or die out completely within the country. The key will be to promote an integrated development of all components, to realize efficient and uniform production of shrimp and development of an industry which can not only survive but excel in an increasingly competitive market.

The Aquaculture Unit of the Ministry of Fisheries can play a prominent role in promoting the integrated development of the various components of the industry, acting as an informational source both for technical questions and simply facilitating communication between all groups working with the shrimp product. In particular, support of a hatchery to ensure production of quality seed as needed will reduce a major constraint to regular production, particularly for smaller farms which cannot afford to have their own hatchery. While PL prices are not a major cost factor, Belize must not risk the possibility of PLs not being available on international markets, at any price.

Aquaculture entrepreneurs in the country may succeed in putting 700 acres of ponds into production in the next ten years. These would produce a yield of 630 short tons annually of shrimp tails. The cooperatives appear to have significant potential to utilize their organization to increase their processing capacities to meet the needs of annual production. Eventually, GOB may wish to promote the production of a local feed to meet the need for 2,600 short tons annually which would be required for the projected yield.

6.0 RECOMMENDATIONS FOR GOVERNMENTAL ASSISTANCE TO PROMOTE SHRIMP MARICULTURE

GOB will ultimately choose how much assistance it wishes to provide to the shrimp mariculture industry in Belize based on the benefits the country as a whole may expect to receive from such activity. The country will experience the benefits of having additional activity in the economy (even if a large proportion of inputs and labor are imported), including employment. While it would be unreasonable for foreign investors to expect a subsidy of start-up and/or operational costs, the Belizean Government can use incentive programs to attract foreign investment and expertise where it is not locally available, but costly support to individual expatriate investors is not warranted, because the benefits to the country as a whole from the existence of any particular industry is not that significant, particularly when compared with other potential uses of GOB resources. Government can also assist in the provision of information so that locally available resources, particularly labor and existing services, will not be overlooked when investors define their operations.

Regarding whether GOB should continue to have shrimp farming as a high priority for investment, the prospects for this industry in the long term are not likely to be significantly affected by monetary incentives to investors in the short term. Under the Ministry of Economic Development, the Office of Economic Development has designed developmental incentives to assist the newly developing industry. Tax holidays, exemption from import duties and stamps, and a recent removal of the 5% export duty on farm produced shrimp all contribute to this incentive package. This incentive package conforms with RDA's recommendation that GOB define a laissez-faire policy toward investors in shrimp culture. Government is not expending funds specifically on behalf of the investors. On the other hand, GOB is not trying to extract revenue from these entrepreneurs. Therefore GOB is not really foregoing much income, for it appears that under present economic conditions, very few enterprises which would tolerate significant taxation would wish to compete for the resources used by the farms.

The following recommendations should be given serious consideration as government develops its action plan:

1) **The government of Belize should continue the incentive programs offering concessions for existing farms.** The five to ten year time-frame for exemptions may be extended for these first pioneers if the government receives sufficient evidence that entrepreneurs are truly pursuing staged development as a result of financial constraints and/or experimental programs which may be undertaken to tailor subsequent development to incorporate new information.

   GOB may wish to acknowledge that entrepreneurs presently in-country have invested significant time and effort in establishing an industry, yet their findings are not yet sufficiently clear to save new entrepreneurs from replicating their efforts. Entry of new entrepreneurs may be premature pending demonstration that regular production can be economically viable within the country.

   Rationale: While other productive activities are not competing for the same resources (primarily abundant coastal land), it is worthwhile to wait

to see if entrepreneurs can succeed in making the area productive (for both themselves and the country) in the long term, without slowing down or stifling the developmental process.

Future farms should also be encouraged to find locations where soil conditions, investment in infrastructure, and accessibility can be optimally combined. The government cannot be expected to construct roads and install electricity to any arbitrarily chosen spot.

2) **The existing (and under construction) farms should be allowed continued "freedom to develop" or "laissez-faire."** They fear any possible governmental decree which might require them to, for instance, purchase feed or seed stock from a Belizean producer or use a local processor when in their own minds the services or products might be inferior to other alternatives.

Rationale: Given the inherent risks in shrimp farming, managers wish to have the maximum number of variables under their control. If not allowed to manage their own production in Belize, venture capitalists will be more inclined to go elsewhere. These farmers will naturally want to use Belizean products/services if and when quality, dependability, and economy are equal to or better than other alternatives. The shrimp industry's situation is presently precarious and GOB intervention, however well-intended, could result in raising the farmer's costs and lowering the quality standards of their inputs, undermine the viability, and eventually destroy the existing industry, and any other industries developed to serve it.

3) **The fisheries unit should be provided with additional staff and support to allow at least the present aquacultural section (staff) to become active in the field as true extension personnel.**

Rationale: Not only can these professionals be very helpful in technology transfer among the farmers themselves, but through becoming trusted by the farmers, they can actually begin to gather some much needed factual information regarding the true status of shrimp pond culture in Belize. In the long run, these government extension agents may eventually help local farmers establish themselves in the aquaculture industry once shrimp culture becomes an established industry in Belize.

There are no secrets in raising marine shrimp. Farmers in Belize are competing in a world market, not against each other. It is simply a matter of economics: cost of production vs. selling price. For this reason, cooperation should be expected from all concessionaires.

In order to facilitate the policymaking process and encourage involvement of local (and foreign) risk capital, detailed records on inputs, production, progress, and future plans need to be available. Shrimp farms cannot expect the government and/or private sector to provide incentives, infrastructure, and direct financial assistance without being able to make a comprehensive evaluation of these data. The Aquaculture Unit should be allowed access to farms to conduct their fact-finding work, and to other departments to check on import and export data. This information should be voluntarily provided by the farmers.

4) **Hatchery and processing operations should be looked at as separate, supporting services by agricultural funding agencies.** For instance, a hatchery system might easily run as a successful business based solely on production for export regardless of whether or not any growout farm is successful in Belize. Similarly, Belize Mills or another local feed mill might be assisted in meeting feed needs for shrimp farms, locally or for export. At present, none of the above are functioning entities capable of handling production levels necessary on a full-time basis.

Rationale: While shrimp growout operations require large venture capital investment and technical expertise to be successful, production of inputs which are critical to the industry have the potential for being produced by Belizeans, increasing national income and reducing some imports.

Furthermore, the industry cannot outgrow its presently precarious position without the development of local sources of inputs.

5) **An effort should be made to strengthen a loosely organized aquaculture association.** This can be done by formalizing a group which would include not only members from the seven existing (and under construction) farms but also members from the academic community, governmental agencies interested in promoting fisheries and economic development, service providers, product users, and laypersons interested in farming aquatic species.

Rationale: A free flow of information will benefit everyone involved in aquaculture. A forum for discussing similar problems can prevent duplication of effort in solving problems. Similarly, if providers of various services are aware of the needs and constraints of other operators in the industry, better working relationships can be established.

6) If credit financing does become available for small satellite farms (and there does seem to be some interest supporting this concept), ensure that each <u>does not</u> attempt to duplicate all the necessities of a large farm.

Rationale: Satellites <u>must</u> share common processing facilities, hatchery or seed stock procurement, feed production, cooperative buying, and water delivery systems in order to be economically viable.

7) **Farmers should be encouraged to make use of the processing facilities and marketing services offered by the cooperatives.**

Rationale: The cooperatives have played a significant role in the development of the capture fisheries product and they have much to contribute to the cultured shrimp product with their organization and infrastructure. By relying on an established institution within the country, shrimp farmers may remove one element of risk in their operations. To date, farmers do not appear to have fully investigated the potential of working with the cooperatives.

Farms which do not have sufficient production for economies of scale in processing, i.e., those with a production of less than 200,000 lbs., can particularly benefit by taking their production to established processing

plants. Cooperative processing facilities are generally of high quality, staff is well trained, and product movement is quick and efficient.

Cooperatives may also be a centralized source of substantial supplies of ice. In cases where distance is excessive, farms should consider acquiring small freezer installations, although this would prevent them from taking full advantage of the qualities of cultured shrimp. Eventually cooperatives may be able to assist in the erection of a processing plant which would be specifically located to cater to the shrimp culture industry.

The cooperatives can also market the products in their own name or in the name of the farmer. Generally the farmer will be able to obtain a better price (with no additional marketing cost) from the cooperatives, as they market the smaller farmed sizes with the larger wild shrimp resulting in an overall better price level. In addition, production from the farms is often in too small quantities to be marketed effectively. Additionally, while dealing through the cooperatives, the farmer does not have to take any trade risk. They will be quickly paid and have no worries about any logistic matters.

APPENDIX A

SITE SELECTION CONSIDERATIONS: HATCHERY/GROWOUT

A. Topography

1. Availability of land (government or private).
2. Elevation of land (minimum 2-3 m above high tide).
3. Soil composition (for construction purposes).
4. Determination of nearest good soil (for construction purposes), if not available on site.
5. Site drainage (the site should be well drained).
6. Elevation of surrounding areas (for gravity-flow, water storage tank construction, if possible).

B. Hydrography

1. Availability of good quality natural seawater.
2. Seasonal current patterns (onshore, offshore).
3. Normal tidal range and storm high tide range.
4. Seasonal flood levels.
5. Observations of the turbidity of the water (hatchery water should be clear).
6. Seasonal variations in water temperature and salinity (minimum salinity in the hatchery should be 28 ppt and minimum temperature in the hatchery should be 28 degrees C.).
7. Availability of good quality fresh water (can be provided by well or trucked in: water should be chemically analyzed for chlorinated hydrocarbons and heavy metals).
8. Examination of site of installation of seawater system intake line (stationary or floating).

C. Pollution

1. Possible sources of pollution should be examined, both historically and projected into the future.
   a) Land, water, air pollutants.
   b) Industrial wastes.
   c) Agricultural wastes.
   d) Aquacultural wastes.
   e) Municipal wastes.

D. Meteorology

1. Prevailing winds.
2. Air temperature.
3. Average monthly rainfall.
4. Incidence of storms and hurricanes.
5. Solar radiation.
6. Evaporation rate.

E. Biology

1. Examination and identification of native phytoplankton and zooplankton species.
2. Testing of water quality from each potential site by bio-assays utilizing Tetraselmis spp or other organisms.
3. Sources of broodstock (trawled from wild stocks or reared in ponds).
4. Location of trawling grounds.
5. Location of fishing ports, docking facilities, and shrimp boat lease fees.

F. Sociology

1. Geographical location of the facility.
2. Competing uses of the environment.
3. Waste disposal uses.
4. Recreational uses.
5. Navigatonal wastes.
6. Utilities (electrical 3-phase, cooking gas, gasoline, oil, diesel fuel, drinking water, sanitary facilities).
7. Schools.
8. Medical care.

G. Labor

1. Availability of labor (men and women).
2. Proximity to site.
3. Skilled vs. unskilled.

H. Infrastructure

1. Accessibility of facility.
2. Road system (paved or dirt).
3. Railroad services.
4. Airports.
5. Sea transportation.
6. Cargo handling facilities.
7. Freight rates.

I. Materials and Services

1. Raw materials.
   a) Fuel.
   b) Ice.
   c) Concrete.
   d) Lumber.
   e) Construction steel.
   f) Fiberglass - plastic.

2. Services.
   a) General contractor.
   b) Plumbing.
   c) Electrical.
   d) Carpentry.
   e) Mechanical.
   f) Water well drilling.

J. Power Costs

1. Public.
2. Private.

K. Personnel

1. Technical staff.
2. Technicians.

APPENDIX B

SELECTED REFERENCES

Aquatic Systems Incorporated Report, 1987. A Study of the Potential for Commercial Pond Aquaculture in Costa Rica.

BEIPU, 1987. Notes on December 14, 1987, Mariculture Meeting at Bird's Isle.

BEIPU/IESC. 1988. Report on October 6, 1988, Mariculture Workshop.

FAO/World Bank, 1986. 96/86 CP-BZE2. Agricultural Credit Project, Annex 3, Shrimp Farming Sub-Project.

Farfante, 1970. Claves Ilustradas Para la Identificacion de los Camarones Commerciales de la American Latina. Comision Nacional Consultiva de Pesca.

Horna, 1984. Guia Para el Transporte y Aclimatacion de Larvas de Camaron. Editorial Series VZ, Guayaquil, Ecuador.

NOAA, 1988. Office of International Affairs, Foreign Fisheries Analysis Branch Report IFR/88-38. Latin American Shrimp Culture Industry, 1986-1990.

Sweat, D. et al., 1987. FUSADES El Salvador Aquaculture Feasibility Study.

USAID. 1985. Low Input Shrimp Farming. USAID Honduras 1314.

Vergne, P. et al., 1988. Study of the Honduran Shrimp Industry.

World Bank Report, 1988, #7011 BEL. Agricultural Credit & Export Development Project, Section 3.15.

Yoong y Reinoso, 1982. Cultivo de Camaron Marino (Penaeus) en el Ecuador Metodologias y Tecnicas Utilizadas Recomendaciones. Boletin Cientifico y Tecnico, Vol V, Numero 2, Guayaquil, Ecuador.