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# A SUSTAINABLE SHRIMP MARICULTURE INDUSTRY FOR ECUADOR

**Edited by Stephen Olsen and Luis Arriaga**

International Coastal Resources Management Project

The University of Rhode Island

# Socioeconomic Aspects of Shrimp Mariculture

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# An Economic Analysis of Trends in the Shrimp Cultivation Industry in Ecuador

# Un Análisis Económico de las Tendencias en la Industria de la Maricultura del Camarón en el Ecuador

Jon G. Sutinen, James Broadus, and Walter Spurrier B.

## Resumen

El documento analiza el estado de la economía de la Industria de la Maricultura del Camarón a mediados de los años 80.

La producción de camarones en escala significativa comenzó en Ecuador en 1952 con buques de arrastre. Hasta 1955 la producción fue menor que 1.000 toneladas métricas (t.m.), se duplicó en 1956 y superó las 3.000 t.m. en 1958. En la década de los 60 aumentó unas 3,5 veces hasta un máximo cercano a 9.000 t.m. en 1969.

Los cambios en la pesca costera están relacionados significativamente con los eventos de "El Niño", en cuyos años el promedio es de 7.900 t.m., mientras en los años de ausencia de este fenómeno el promedio baja a 6.300 t.m. Las variaciones en la productividad no se explican totalmente con los eventos de El Niño, por ello deben tenerse en cuenta razones económicas, variaciones en la flota y otras condiciones.

La industria del cultivo del camarón se desarrolló en la década 1976-1985. En 1976 la producción fue de 9.000 t.m. y alcanzó un máximo de 44.600 t.m. en 1983 (35.700 t.m., de cultivos). En 1984 y 1985 la producción en estanques cayó a 33.600 y 30.205 t.m., respectivamente, lo que fue atribuído a falta de postlarvas para la "siembra".

En 1985 habían tres tipos de cultivo: (1) extensivo (rendimientos: 600 lbs/camarón entero/ha/año); (2) semi-extensivo (rendimientos: 2.150-2.400 lbs); y, (3) semi-intensivo (rendimientos: 3.000-5.000 lbs). No hay registros adecuados para estudios de costos-beneficios.

El factor decisivo en el cultivo es el aporte de postlarvas (pls), que proviene de tres fuentes: pesca, laboratorios e importación. Se estimó que unos 90.000 pescadores, a tiempo parcial, se dedicaron a la captura de pls en 1983; que desde 1979 se han usado entre $4x10^9$ y $11x10^9$ pls/año; que la producción de laboratorios en 1984 fue de unos 300 millones de pls.

A fines de 1985 la superficie autorizada para construcción de piscinas alcanzó las 94.000 has y el máximo probable en cultivo fue de 48.000 has en 1984, disminuyendo en 1985 a unas 30.000 has. Más del 75% de la superficie autorizada correspondió a la provincia del Guayas, el 15% a El Oro y el resto a Manabí y Esmeraldas (1985). Los suelos usados para piscinas corresponden a: manglares (70%), salitrales (15%) y tierras agrícolas (15%). Se estima que el total de suelos disponibles para cultivo está entre 70.000 y 260.000 has.

Antes de 1980 el número de empacadoras de camarón eran menos de 20, pero para 1985 el número es superior a 70. El 10% de las empresas exportaba el 45% del camarón, entre 1982 y 1984. El valor de las exportaciones creció desde menos de 25 millones de dólares (E.U.A.) en 1976 hasta cerca de 185 millones en 1983, constituyendo el segundo rubro en el ingreso de divisas y el 7% del valor de todas las exportaciones del país. El principal destino de las exportaciones son los E.U.A. y sólo un 4% se envió a Japón y Europa. Hay informaciones de envíos informales de camarón al Perú, desde donde se exporta.

Los créditos concedidos a la industria del camarón hasta mediados de 1980 fueron por el Banco Central del Ecuador en 300 millones de dólares, principalmente a través de bancos comerciales. También, han jugado un papel importante las inversiones extranjeras.

El documento presenta informaciones sobre las políticas de Gobierno y los incentivos establecidos para el desarrollo de esta actividad y plantea recomendaciones que, fundamentalmente, son de dos tipos: (a) cambios en las políticas tendientes a reducir el contrabando y extender los plazos de las concesiones de suelos para piscinas o hacer renovaciones automáticas; y, (b) investigaciones y organización de las informaciones, debiendo atenderse aspectos como determinación de costos, evaluación de la demanda de pls, calidad del producto, condiciones del mercado internacional, etc.

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## Introduction

This paper is an attempt to document and analyze the economic status of the Ecuadorian shrimp mariculture industry in the mid-1980s. Where possible, the likely economic impacts of prevailing policies on the industry and the Ecuadorian economy are explained. Full economic analysis would be possible only with much more extensive research.

## Early History (1952-1975)

Production of shrimp on a significant scale began in Ecuador in 1952 with the introduction of offshore trawlers. Offshore production was under 1,000 metric tons (m.t.) through 1955, more than doubled in 1956, and exceeded 3,000 m.t. for the first time in 1958. Production by shrimp trawlers paralleled growth in the fleet and increased by nearly 3 1/2 times in the 1960s, peaking at nearly 9,000 m.t. in 1969. Double-rigged trawlers were first introduced in 1960, and the number of trawlers increased by 2 3/4 times in the decade, totalling nearly 250 vessels in 1969 (Table 1).

By 1970, the offshore fishery for shrimp had fully developed. In the 1970s the offshore trawl fishery experienced cyclical variations in production and fleet size. During 1970-71, offshore production fell to about 6,000 m.t. each year. In 1972, production rebounded and reached nearly 8,000 m.t. in 1973. Production again dropped to a modest 6,500 m.t. in 1974, but reached 7,500 m.t. in 1975. The number of trawlers peaked at 276 in 1972, and then declined to just under 250 by 1975. Hence, by the middle of that decade, the production sector of the offshore shrimp fishery had reached maturity. The resource was fully exploited, and the fleet size appeared to be oscillating about its long-run maximum.

Changes in offshore production also correlate significantly with El Nino events. These climatic events typically begin during December or January, last from two months to two years, and enhance shrimp production with much higher than normal air and water temperatures, precipitation and sea level.

El Nino events occur regularly, usually every five to seven years, affecting abundance and, hence, production for one to two years. Full offshore production in non-El Nino years averages 6,300 m.t., while in El Nino years production averages 7,900 m.t., a 27 percent difference (using the mean production level of 7,000 m.t. as a base). In short, the offshore shrimp fishery is subject to wide variation in production and economic fortune due to natural environmental changes alone. Table 2 shows the incidence of El Nino events and their severity. The El Nino of 1958 may have begun the year before, and may have been severe. The principal point, however, is that substantial increases in offshore shrimp production occurred at this time. Peaks in offshore shrimp production also coincided with the El Nino events in 1965, 1969 and 1973.

Still, changes in productivity do not explain all changes in the fleet size, and El Nino events do not explain all changes in production. Clearly, economic and other conditions would also explain a good part of the trends in the offshore shrimp fishery during 1952-1975. Unfortunately, the data needed for a complete analysis are not available.

The shrimp industry in Ecuador has been export-oriented almost from its beginning. The first exports of shrimp occurred in 1954, two years after offshore trawling began. Two packing firms were established in these early years. No data are available on processing and marketing activities prior to 1970. The volume of reported exports peaked at 5,000 m.t. (product weight) in 1972, and the value peaked at U.S. $14.6 million in 1975 (Table 3).

Freight on board prices in current U.S. dollars rose fivefold during the period and, even after adjusting for inflation, prices exhibited a healthy threefold increase overall from 1970 to 1975. Slightly more than 80 percent of Ecuador's shrimp production was exported during 1970-75, 97 percent of that to the United States. Still, only 3 percent of all shrimp exports to the United States during the first half of the 1970s came from Ecuador, though the situation began to change by the end of the decade. Imports of Ecuadorian shrimp by the United States began in 1954 (Table 4). The quantities of imports between 1954 and 1975 equal the quantities of production. Slight discrepancies between the U.S. import and Ecuadorian export data may be due to different recording procedures.

## The Past Decade, 1976-1985

Just as the decade of the 1960s saw development of the offshore shrimp fishery, the past decade witnessed development of the shrimp cultivation industry in Ecuador. Total production and exports of shrimp rose fivefold (in weight) due to the growth of shrimp farming in the country so that Ecuador is now the second largest supplier of shrimp imports to the United States. The success of shrimp mariculture in Ecuador has prompted large-scale investments in similar shrimp cultivation operations in Panama, Brazil and other tropical countries.

### Total Shrimp Production

In 1976, total shrimp production was 9,000 m.t., while in 1983 production peaked at 44,600 m.t.. Cultivated shrimp comprised a small fraction of total production in 1976, but by 1983 cultivated shrimp may have comprised 75 percent of the total (Table 5).

Modern shrimp farming on a commercial scale began in 1968 or 1969. The first ponds were built in El Oro province by individuals involved in the banana industry. Yields were initially low and total production was insignificant compared to offshore trawl production. By 1974, about 600 hectares were in production (McPadden, 1985). By 1977, entry into shrimp cultivation was like a "gold rush" (Hirono, 1983), though production probably remained relatively small through 1978. The first year of significant cultivated production in 1979, at nearly 4,700 m.t., was still less than offshore production. Then, in 1980, cultivated production nearly doubled to almost 9,200 m.t., and exceeded offshore production for the first time. Cultivated production continued to expand into the early 1980s. Official estimates show production growing by 32 percent and 78 percent in 1981 and 1982, respectively. In 1983, estimated cultivated production peaked at 35,600 m.t., an increase of 66 percent over 1982. If these estimates are reasonably precise, they show that cultivated production increased 7 1/2 times from 1979 to 1983, a remarkable achievement in any industry.

The production increases of 1982 and 1983 may be largely attributed to favorable environmental and economic conditions (abundant postlarval shrimp and a strengthening U.S. dollar). However, according to official estimates, cultivated production dropped to 33,600 m.t. in 1984 and 30,200 m.t. in 1985, due presumably to the lack of postlarvae for stock ponds.

Accurate data on the current number and size of shrimp farms in Ecuador are not available. Only the number of hectares authorized for cultivation by the government is known. It is likely that for much of the period through 1980, authorized hectares were considerably less than the actual area used in the shrimp farming. Since 1981, however, it appears that the actual area in farms was less than the authorized hectares (Table 6). These data do not distinguish between land area of farms and land area in ponds. Also, we do not know how much of the stated area was idle in a given year.

### Farm Operations

While shrimp cultivation originated in El Oro province, the greatest expansion occurred in Guayas province in the islands of the Estero Salado and on the northwestern banks of the Estero. According to McPadden (1985), the expansion was facilitated by abundant quantities of intertidal mangrove areas and salt flats which could be developed at low cost, and an abundance of postlarval shrimp. Relatively modest development of shrimp farming also occurred in the provinces of Manabi and Esmeraldas. Table 7 shows the numbers and areas of government concessions for shrimp farming by province over the last decade. These data should be treated as indicative only, since, as stated above, government authorizations are not an accurate record of the actual amount of land cultivation.

The size of shrimp farm operations appears to vary greatly. Many farms are small, producing small amounts of shrimp on a few hectares of land while, at the other extreme, there are a few large farms of several hundred hectares with large production levels. At least one large farm is part of an integrated firm which owns a fleet of trawlers and is a major exporter of shrimp. There are no data showing production by farm, therefore, we do not know if the bulk of cultivated shrimp is produced by a few large farms or by

several small farms. A description of the area of lands awarded in 1984 is given in Table 8, excluding a few large farms of 1000-2,000 hectares.

As of early 1985, there were three types of farm operations in Ecuador: (1) extensive, (2) semi-extensive, and (3) semi-intensive. The extensive method is the simplest. Ponds are stocked at low densities, no supplemental feed or fertilizer is used, water exchange is minimal, and yields are low (about 600 pounds of whole shrimp per hectare, per year). The extensive method is common on small farms and on the older farms of El Oro province where shrimp cultivation originated (McPadden, 1985).

The semi-extensive method is distinguished from the extensive method by the use of nursery ponds (to grow the postlarvae to the juvenile stage before transfer to growout ponds), higher stocking densities, fertilization of ponds, supplemental feeding near the end of the growth cycle, and regular monitoring of the pond environment and shrimp biomass. Yields are from 2,150-2,400 pounds of whole shrimp per hectare, per year. The semi-extensive method is common in Guayas province on farms of 100 hectares or larger (McPadden, 1985).

The semi-intensive method is distinguished by still higher stocking densities, the use of fertilization and supplementary feeding throughout the growth cycle, and high exchange of water. Yields are the highest of the three methods, from 3,000-5,000 pounds of whole shrimp per hectare, per year (McPadden, 1985).

There is no record of the percentage of Ecuador's cultivated production committed to each method. Li Puma and Meltzoff (1985) claim that the exensive method is used for 35 percent of the shrimp ponds, the semi-extensive method for 55 percent, and the semi-intensive method for 10 percent. If this distribution and the above yields are reasonably accurate, then farms using extensive methods account for only 9 percent of total cultivated shrimp production, semi-extensive for 58 percent, and semi-intensive for 33 percent. These shares were calculated using the upper end of the range for yields per hectare given above. These higher yield values are consistent with estimated cultivated production and estimated area actually in cultivation in 1984.

## Production Practices

No detailed account is available of the production practices followed for each method of farming. McPadden (1985) describes the practices of the semi-extensive method as follows: upon purchase, postlarvae are first stocked in nursery ponds, which have been fertilized. The stocking density in the nursery ponds is 1 million postlarvae or more per hectare. After about 45 days growing in the nursery ponds, the juvenile shrimp are transferred to growout ponds at lower densities. The growout ponds are stocked at 30,000-35,000 juveniles per hectare, and fertilized to enhance phytoplankton, a primary source of nutrition for the shrimp. The ponds are regularly monitored for primary productivity, oxygen levels, biomass and growth. Near the end of the growth cycle, when the shrimp attain an average weight of 12 grams, special feeds are added to the ponds. We do not know the usual length of the growth cycle for this method. (McPadden reports the growout period for the semi-intensive method is 120-140 days). Harvests occur about twice a year, synchronized to the availability of wild postlarvae for stocking.

According to Barniol (1980) the decision to harvest is determined by the weight of the shrimp and their growth rate, the market price, and the extent of predation (by crabs, ducks and human thieves). Harvest is accomplished by partially draining the pond and using throw nets to capture the shrimp, or by completely draining the pond and capturing the shrimp as they leave the pond with the water. After harvest, ponds are completely drained and dried, the bottom is cleaned and leveled, and repairs are made to canals, walls, etc. After refilling the pond with water, fertilizers are applied before restocking.

Harvested shrimp presumably are taken to a processing and packing plant; however, no description of handling, transport and other methods is available.

## Costs and Earnings

A complete and accurate record of the costs and earnings of production in the cultivated shrimp industry is needed before the following important issues and questions can be addressed:

- How have the costs and earnings shaped past developments in the industry, in terms of farm size and number, location, methods used, stocking densities, feed use, etc.?
- What are the major determinants of profit and loss?
- What is (are) the most profitable type(s) of farm(s) in terms of size, and stocking, feeding and harvest methods?
- Can the costs of entering the industry be recovered over a reasonable period?
- Given the current costs and earnings picture and general trends, what developments in the industry can be expected in the near future?

Unfortunately, adequate records are not available at this time. The most complete costs and earnings data available are a survey of the industry conducted by the Central Bank of Ecuador (1982). This study gives the average production costs and prices per pound on 112 farms in four provinces for the years 1979, 1980 and 1981. Table 9 summarizes some of the results of the Central Bank's study. Unfortunately, we do not know farm size distributions in the study's cost figures, which makes interpreting gross margins difficult. A study by Liao and Chao (1983) reports average production costs of 15-27.5 sucres per pound for the extensive cultivation method. However, neither characteristics of the farms on which this estimate is based, nor a description of the items included in their cost figures are given, and no information is provided on earnings. McPadden (1985) reports average production costs in the range of 220-270 sucres per pound for farms using semi-intensive methods. LiPuma and Meltzoff (1985) cite costs of abut 120 sucres per pound for farms using semi-intensive methods. They also report costs of 113 and 161 sucres per pound for extensive and semi-extensive farming methods.

Disparity among these data make them difficult to use. Furthermore, recent data given by McPadden, and LiPuma and Meltzoff are based on an inadequate sample of farms in the industry, and cannot be used to draw any firm conclusions. The systematic survey conducted for the Central Bank's study make these data most credible. However, the results are not presented in a form useful for present purposes.

## Production Inputs

The principal inputs to the cultivated production process include postlarval shrimp, land, water, human capital, and physical capital. Other inputs include feed and fertilizer. Clearly, the availability and quality of these inputs affect farms' performance and determine the condition of the industry.

### Postlarvae

Perhaps the single most critical input in shrimp cultivation is the postlarvae, or seed shrimp. Two species, Penaeus vannamei and Penaeus stylirostris, have been successfully cultivated on a commercial scale in Ecuador. Of the two, P. vannamei appears to provide the greater economic return. There are three distinct source of postlarvae supply in Ecuador: fisheries, hatcheries, and imports from outside the country.

The total quantity of postlarvae used by all farms for shrimp cultivation is not known. Table 10 presents the few available estimates of postlarvae use. If the basis for these estimates is sound, then it appears postlarvae use has ranged from 4 to 11 billion a year since 1979.

The actual quantities of postlarvae used are largely determined by the interaction of demand and supply conditions. Although these have not been studied and documented, the following are reasonable suppositions: The quantity demanded at a given time depends on the area of ponds available for stocking

and desired stocking densities. These, in turn, depend on the production methods used, the expected selling price for grown shrimp, and the purchase price of postlarval shrimp. The quantity supplied depends on the natural abundance of postlarvae, the methods and their costs of harvesting, handling and delivering them to the farms, and their selling price. If the market for postlarvae is working well, the price of postlarvae rises or falls until the quantity demanded equals the quantity supplied, and no one is willing to buy or sell more at this market equilibrium price.

Because the information on the economics of the farms is incomplete, an analysis of postlarvae demand is impossible. To explain and predict some important events in the industry, a comprehensive analysis of postlarvae demand conditions should include:

- the quantitative relationship between the price and quantity demanded of postlarvae by firms, including the price at which postlarvae demand would be completely choked off
- which farms (by type, size, etc.) would and would not stock at various prices
- how stocking rates are affected by changes in postlarvae price
- how postlarvae demand is affected by shrimp export prices and other factors

### Wild Postlarvae

During the period 1976-1985, wild postlarvae accounted for nearly all of the postlarvae used in cultivated production. Until hatcheries become a significant source of supply, the availability of wild-caught postlarvae will continue to be a major determinant of the status of shrimp production in the country.

No records exist on the number of fishermen in the postlarvae fishery over the years. A report by the National Marine Fisheries Service (NMFS) (1981) estimated 2,000-3,000 artisanal fishermen collected postlarvae in 1980. Assuming, conservatively, that 5 billion postlarvae were caught and sold by fishermen at 25 sucres per thousand, gross earnings to postlarvae fishermen amounted to 125 million sucres. Various sources estimate 90,000 or more fishermen participated in the postlarvae fishery in 1983. McPadden (1985) estimates their gross earnings per postlarvae fisherman fell from 42,500 sucres (U.S. $1,700) or more in 1980 to 10,000 sucres (less than U.S. $120) in 1983. Since inflation, as measured by the consumer price index, more than doubled during this period, the fall in real average earnings was even more dramatic.

These estimates should be treated as indicative only because many of the 90,000 postlarvae fishermen in 1983 worked part-time in the fishery. Also, it is common in most production activities for a small proportion of producers to supply a large share of the product (here, postlarvae). If this was the case, the more productive postlarvae fishermen were earning much more than these estimates indicate. A report by NMFS (1985b) that fishermen who shifted to the postlarvae fishery have been able to buy motors and replace their dugout canoes with fiberglass boats supports this conjecture. In fact, many postlarvae fishermen have seen their income increase by two to tenfold or more (Maugle, 1986).

Brokers, or intermediaries, commonly purchase the postlarvae from fishermen and transport them in tanks and barrels to sell to farms. According to LiPuma and Meltzoff (1985), the brokers' markup is from 100 to 150 percent. Other reports indicate much larger markups. The price of a tank is established by estimating the number of living P. vannamei and P. stylirostris postlarvae it contains (McPadden, 1985). Table 11 presents available data on postlarvae prices. Two prices are given: the price paid to fishermen by brokers and the price paid to brokers by shrimp farmers. Unless noted otherwise in the source document, the report price is assumed to be the price paid by the farmers.

Unfortunately, the price data are incomplete and difficult to intepret. January, February and March are usually times of relative abundance and, therefore, should have the lowest prices in a given year. Similarly, the last half of a year usually corresponds with relative scarcity, and prices should be highest. The data are consistent with these expectations, but comparing prices across years is more tenuous.

The nominal prices for February in 1984, 1985 and 1986 are about the same. However, after adjusting for inflation (by the imperfect method of dividing by the consumer price index), real postlarval prices for February have declined. This price decline may have been caused by an improvement in supply conditions, or a weakening of demand conditions, or both, over these two years. Supply conditions could have improved, for example, due to an increase in postlarvae abundance and/or increased efficiency in capturing, handling and transporting methods (all of which have been reported; see McPadden, 1985, and NMFS, 1985b). Demand conditions could have weakened, for example, if the costs of farm operations rose and/or if the selling price of shrimp fell. There is no evidence that postlarvae became available from

alternative sources (i.e., hatcheries, imports at competitive prices), but another possible reason for weakened postlarvae demand, if it weakened at all, may have been the fall in the area of ponds cultivated from 1984 to 1985. If ponds could have been readily brought back into cultivation with low set-up costs, then the reduction in pond area would not have weakened demand. On the other hand, if restarting ponds was a slow and costly proposition, then the reduction would have weakened the demand for postlarvae.

While not shown in Table 11, postlarvae prices also vary geographically. They are highest in Guayas province, where most ponds are located, and lowest in Manabi (LiPuma and Meltzoff, 1985).

### Hatchery Production

The future of shrimp cultivation in Ecuador depends in large part on hatcheries. To date, the production of postlarvae in hatcheries has been limited, with negligible effects on total supplies of postlarvae.

The first hatchery was established in Guayas province in 1980. By the end of 1984, four hatcheries were in production and 14 others in various stages of development. McPadden (1985) estimated these hatcheries to have a maximum production potential of 2.4 billion postlarvae per year. Hatchery production in 1984 was less than 300 million postlarvae (NMFS, 1985b). Various sources indicate that by the end of 1985, from five to 30 hatcheries were in production, with 30 more planned, and production that year exceeded 500 million postlarvae (Leslie, 1986). The rapid increase in hatchery development in 1984 and 1985 was clearly induced by the dramatic drop in wild postlarvae supplies in 1984.

If hatcheries are to make a significant contribution to the development of shrimp cultivation they will have to be commercially viable. The few reports available suggest that hatchery production costs were about 500-600 sucres per 1,000 postlarvae in 1985 (NMFS, 1985a; Maugle, 1986). Data from Leslie (1986) indicate minimum average prices required to make hatchery operations commercially viable (Table 12). The calculated prices suggest that small "bamboo" type hatcheries may be able to compete with supplies of wild postlarvae even during periods of relative abundance, while "high-tech" hatcheries, requiring higher prices, would be viable only during periods of relative scarcity.

A number of qualifications should be made regarding the calculation and meaning of the minimum average prices shown in Table 12. First, the prices are sensitive to the interest rate. For example, using the lower rate of 20 percent reduces the price by 65 sucres for the large, high-tech hatchery. Second, using the lower end of the range of production costs results in a lower price (e.g., the "bamboo" hatchery price would be 340 sucres).

A third qualification is that hatchery-produced postlarvae may have a greater or lesser value to growers than wild postlarvae. For example, if survival rates for wild postlarvae are higher than for hatchery postlarvae, then the price that farms are willing to pay for hatchery postlarvae will be less. The difference in the two prices will be proportional to the difference in their survival rates, assuming no other differences.

### Imports of Postlarvae

Another source of postlarvae is importation. Postlarvae have been imported from several Latin American countries, the United States and the Philippines. During the height of scarcity in 1985, prices of imported postlarvae were reported to be about 2,500 sucres per 1,000. Shipping problems reportedly eliminate imports from countries other than Peru as a significant source of supply.

### Land

Data on land use in shrimp cultivation reveal the following: the amount of authorized land increased monotonically during the period 1976-1985, reaching 94,000 hectares at the end of 1985. The amount of land actually in cultivation rose continuously through 1983 or 1984, probably peaking at about 48,000 hectares, and then dropped off in 1985 to about 30,000 hectares. The amount of land converted to shrimp cultivation is always greater than the amount actually in cultivation. For example, 60 percent of the converted land was not in production in 1985 (LiPuma and Meltzoff, 1985).

As of 1985, over 75 percent of the land authorized for shrimp cultivation was located in Guayas province, 15 percent in El Oro province, and the remainder in Manabi and Esmeraldas provinces, though it is not clear to what extent land actually in cultivation follows this pattern.

There are three types of land converted to shrimp cultivation: mangroves, salt flats and agricultural land. According to LiPuma and Meltzoff (1985), at the end of 1984 about 70 percent of the land used for cultivation was converted mangroves, 15 percent was converted salt flats, and 15 percent was converted agricultural land. Other estimates, based on aerial photography are given by Alvarez (this volume). Mangroves and salt flats lie in the intertidal zone and agricultural land lies above water at high tide. Table 13 shows the distribution by land types authorized for 1983 and 1985. These data suggest a trend toward using more agricultural land.

The shift to agricultural land appears to be due to three factors (LiPuma and Meltzoff, 1985):

- Prime land in the intertidal zone is becoming harder to obtain.
- There is a shift towards more intensive cultivation methods for which agricultural land is more suited.
- Farms located in the intertidal zone cannot be used as collateral for loans since the government retains title to the land.

Estimates of the amount of land available for shrimp farming operations range from 70,000 to 260,000 hectares (McPadden, 1985). These estimates are not very useful for defining the potential of shrimp cultivation in Ecuador, however. As the industry expands, new farms are faced with using land which requires higher investment costs, or higher operating costs, or both. The quantity of land suitable for commercially viable shrimp cultivation will ultimately be determined by the costs and earnings of farms on marginal land. McPadden (1985) suggests that these economic forces are already being felt in El Oro, Manabi and Esmeraldas provinces where higher development and water pumping costs are limiting the expansion of shrimp farming.

Data on land prices have the potential for explaining changes in the industry, and signaling future trends. As the industry expands one would expect the price for prime land to rise, and the price of increasingly marginal land to fall. The few price data available do not distinguish the quality of the land involved and, therefore, interpretation of land price behavior is not possible.

An important feature of land use for shrimp cultivation is that the intertidal zone land (converted mangroves and salt flats) is owned by the government. Individuals, or groups of individuals, are granted 10-year concessions to develop and operate shrimp farms on these lands. A concern is whether the concession is sufficient to bring about the best development and use of the land, and also whether it provides an adequate return on certain investments in a farm. Short tenure induces practices that result in near-term benefits and, possibly, in costs delayed to after the life of the concession. Short concession periods are not in the interest of its owner, and may not be in the interest of the larger society. Unfortunately, without more information and more study, it is impossible to determine the optimal period of a concession. One solution would be to make concessions continuously renewable, provided certain specified terms are always satisfied by concession owners.

### Labor

Shrimp cultivation and ancillary activities employ significant numbers of people. For the 1980-81 period, local sources estimated employment at about 40,000, most as farm laborers, and 2,000-3,000 fishermen collecting postlarvae (NMFS, 1981). For the 1983-84 period, Parodi (1985) cites estimates of 25,000-45,000 people employed on farms and boats, in packing plants, hatcheries, feed mills, ice plants, and other service industries (these estimates are for the entire shrimp industry, not just cultivation). In addition, there were 90,000-120,000 people just collecting postlarvae. The total employment on shrimp farms is not known. LiPuma and Meltzoff (1985) report the largest operations employ about 70 men, while farms of less than 50 hectares tend to employ less than a dozen full-time people, hiring temporary labor for construction and harvest assistance.

It is not evident how dependent shrimp cultivation is on skilled labor. Hatcheries, as noted above, are highly dependent on skilled technicians. The salaries skilled labor commands and what farms are willing to pay are topics for further investigation.

As the industry evolves, employment may decline. The successful development of hatcheries may eventually displace people employed in collecting wild postlarvae. If farms move toward more intensive cultivation methods, fewer but more skilled laborers may be required.

### Equipment

Most of the equipment used in the industry, including diesel engines, pumps, graders, refrigeration, earth moving and hatchery equipment, is imported from the United States. NMFS (1981) estimates that imports of U.S. equipment for the shrimp industry was as much as U.S. $10 million per year in the early 1980s.

## Trawler Production

Official statistics do not separate offshore trawler and farm-raised shrimp production after 1975. Some estimates (cited in McPadden, 1985) indicate offshore trawl production was fairly stable and healthy, at between 7,000-8,000 m.t. during the latter part of the 1970s. Other sources (NMFS, 1981) claim that a drought, which began in 1977 and lasted until 1981, reduced the abundance of shrimp and resulted in trawler catches substantially below previous levels. Most reports indicate that the fleet size remained fairly stable around 250 vessels during the late 1970s.

Both 1981 and 1982 were difficult years for the offshore trawl fleet. The government increased fuel prices substantially and owners of fishing vessels went on strike for 40 days. Some sources report trawl production below 5,000 m.t. for 1981 and that as many as 50 vessels abandoned shrimping in 1982 (Department of State, 1981, 1982). Shrimp trawlers were being sold at low prices and converted to other fisheries. The El Nino event of late 1982 and 1983 dramatically improved the fortunes of the shrimp trawl fishery. Sources report trawl catches of 9,000-15,000 m.t. during 1983 (Department of State, 1984; McPadden, 1985). Also in 1983, no shrimp trawlers were available for sale, and several vessels from other fisheries were converted to shrimp trawling. Offshore production dropped sharply in 1984 with the passing of the El Nino event, with production per vessel perhaps as low as 20 m.t. (Parodi, 1985).

## Processing and Marketing

The development of shrimp cultivation has had a beneficial impact on the processing and export sector. Initially, packers opposed the development of shrimp ponds, fearing that pond construction and collection of postlarvae would cause trawler catches to decline. Since then some of the larger packers have become some of the major owners of shrimp ponds.

Shrimp are processed and packed by several firms and nearly all of the product is exported. Details on the processing and packing practices are not available, but the number of firms has grown substantially. Prior to 1980, the number of packing firms totalled less than 20, whereas their number exceeded 70 by 1985.

The available evidence suggests no serious problems with the structure and performance of the processing and exporting sector. Additional firms have been able to enter, and the product is reasonably well distributed among the many firms. Ten percent of the firms exported about 45 percent of the product (by weight and value) during 1982-84. The largest firm in recent years, Enaca, has had its share of product exported fall from 20 percent in 1980 to 10 percent in 1984.

The quantity and value of shrimp processed and exported paralleled the growth of production during 1976-1985. Table 14 shows that the value of shrimp exports rose from less than U.S. $25 million in 1976 to nearly U.S. $185 million in 1983. These export values represent foreign exchange earnings for the national treasury.

In 1980, shrimp constituted the fourth most valuable export commodity (preceded by petroleum, bananas and coffee). In 1983 and 1984 shrimp was the second most valuable export commodity. But in 1985, shrimp returned to fourth place. At its peak in 1983, shrimp accounted for 7 percent of exports (by value), and in 1985 for less than 6 percent.

The export values do not represent the value of gross sales by exporting firms. Foreign exchange must be converted to sucres through the central bank at rates below free market rates. In Table 15, the U.S. dollar amount of shrimp exports has been converted to sucres at the official exchange rate for 1981 and 1982, and at the intervention rate for 1983-1985. The rate at which exporters were allowed to convert U.S. dollars increased from 24.80 sucres to 70 sucres in March 1983. This increase in the exchange rate plus the increase in production resulted in a nearly fourfold increase in exporters' sales in 1983 over 1982. Even when adjusted for the increase in the general price level, the increase in real sales was nearly 150 percent.

The amount of product available for export decreased in 1984 and 1985. Estimated sales decreased in 1984 and increased in 1985, due to increases in the intervention exchange rate. However, real sales fell due to overall inflation.

These sales estimates do not include the export tax credit provided to the industry. In recent years the tax credit has equalled 15 percent of export prices (FOB) value converted at the lower official exchange rate. Since the credit is payable in 15 months and at zero interest, most exporters sell their tax credit certificates at a 50 percent discount (Parodi, 1985). The net result of the tax credit is five additional sucres for each U.S. dollar of exports, or about 1 billion sucres added to the estimate of a year's sales.

Table 16 presents average export prices (FOB) over the decade, with the U.S. dollar prices converted to sucres at the official and intervention exchange rates to provide estimates of prices received by exporting firms. Once again, the switch to the higher intervention rate in 1983 greatly benefited exporters. Their price nearly tripled. In real terms, however, the price rose by about 75 percent from 1982 to 1983, and declined significantly through 1984 and 1985.

Few data are available on the prices paid by packers to farms, so an analysis of price margins cannot be conducted. The Banco Central (1982) study found the average farm price in 1981 to be 60 sucres per pound. If the estimate of 1981 exporters' selling price is correct, a margin of only 18 sucres (30 percent) per pound remained to cover packing, storage and other costs. If further study shows such thin margins, just covering packers' costs, there would no reason to be concerned about the pricing policy pursued by packers in the industry.

As indicated above, most shrimp have always been exported. Through about 1981, 80 percent or less was exported; but in 1984, 99 percent was reportedly shipped out of the country. The principal destination of shrimp exports has been the United States, with only about 4 percent shipped to Japan and Europe. The domestic market for shrimp is small. For a number of years the government required 20 percent to be sold domestically, but in 1983 this requirement was reduced to 4 percent. While the requirement has not been wholly successful, the extent to which it has disrupted marketing activities is not known and harmful inefficiencies may have been introduced in the system by attempts to enforce this requirement.

Reports of informal transfer of shrimp to Peru for export because of more favorable exchange and tax credit rates are common. Although the extent of this smuggling is not documented, some reports indicate it is substantial. Recorded United States imports of shrimp from Peru increased from less than 1,000 m.t. in 1980 and 1981 to over 4,000 m.t. in 1983. Recorded imports for 1984 and 1985 were 3,000 m.t. and 2,000 m.t., respectively (NMFS, 1986). Some informed observers argue that Peru's small shrimp industry is capable of producing for export no more than 1,000 m.t. on average, and possibly 2,000 m.t. in good years (such as 1984). The difference of 1,000-2,000 m.t. (5 to 10 percent) is likely comprised of Ecuadorian shrimp smuggled out through Peru. This amounts to annual losses to the government of Ecuador of $30 million to $40 million in foreign exchange earnings, plus $10 million to $15 million in tax revenues resulting from the differences between the intervention and free market exchange rate. To significantly reduce the difference with the free market rate would help greatly to reduce the extent of smuggling.

## International Markets

As indicated above, nearly all (96 percent) of Ecuador's shrimp exports are to the United States. Small quantities are shipped to Japan and occasionally to Europe.

## U.S. Imports of Ecuadorian Shrimp

In 1976 Ecuador was already the fourth largest supplier of shrimp imports to the United States, accounting for 4 percent of all U.S. shrimp imports. Mexico was the largest supplier, with 35 percent, followed by India, with 18 percent, and Panama, with 5 percent. By 1980, Ecuador took over as the second largest supplier of U.S. shrimp imports. Mexico still held a 35 percent share of imports, but Ecuador's share rose to over 9 percent. Panama and India were third and fourth, with 6 percent shares. In 1983, the year of peak production and exports, Ecuador's share climbed to 15 percent. Mexico's share declined to 25 percent, and India was a strong third at 9 percent. Table 17 lists the quantities and values of U.S. imports of Ecuadorian shrimp. Imports by weight doubled from 1976 to 1980, and increased 2 1/2 times from 1980 to 1983. The quantities imported declined in 1984 and 1985 due to the postlarvae shortage. Average price (the unit value) rose steadily from about $2.75 per pound of tails in 1976 to about $3.35 in 1980, and to about $4.25 in 1983. Prices fell to just under $4 in 1984, and further to about $3.75 in 1985.

With both quantity and price decreases in 1984 and 1985, overall value fell by nearly 25 percent from 1983 to 1985. Despite the setbacks, Ecuador remained second only to Mexico as the largest supplier of shrimp imports to the United States.

## U.S. Market for Shrimp Imports

The United States is the world's leading consumer of shrimp. As one of the most popular seafood commodities, shrimp is sold in various product forms, including (1) raw tails with the shell on, (2) raw peeled tails, (3) breaded, and (4) canned. Most of these product forms (1-3) are marketed frozen.

Imported shrimp tend to flow through the same channels of distribution as domestically produced shrimp. Importers sell to processors, who in turn market their products through brokers and wholesalers. NMFS (1981) reported that three U.S. based importers purchase more than 50 percent of all Ecuadorian shrimp shipped to the United States. Two of these firms were known to have sizeable investments in shrimp companies in Ecuador.

The brokers and wholesalers distribute the shrimp products to institutional and retail outlets. The majority of shrimp reaches U.S. consumers through institutional outlets, i.e. restaurants, hotels, cafeterias schools, hospitals, and the military. As much as 80 percent of the shrimp supply is believed marketed through the institutional trade. The remainder is sold to the final consumer through retail stores, such as fish markets, supermarkets and grocery stores. Most canned shrimp are marketed by the retail sector, and most breaded and raw tails, shell-on shrimp are sold by institutional outlets.

The majority of shrimp imports enter the U.S. as raw tails with the shell on. In 1984, for example, two-thirds of U.S. shrimp imports were of this form. Raw peeled shrimp accounts for most of the rest of U.S. shrimp imports.

Mexico and Ecuador are the two principal suppliers of raw, shell-on imports, with about 30 percent and 20 percent shares by value, respectively. Ecuador's share of this market has grown from 12 percent by value in 1980. Table 18 presents the available data on these imports.

In the raw, shell-on product form, size is an important market feature. According to a NMFS survey (Newman et al., 1985), the predominant sizes imported were 31-40 shrimp per pound during 1980-84. Imports from Ecuador are mainly in this size range. The U.S. market also appears to distinguish country of origin as an important characteristic of shrimp. Vondruska (1986) found statistically significant differences between the prices of Ecuadorian and Gulf of Mexico white shrimp. The prices of Ecuadorian white shrimp in the 26/30, 31/35, and 36/40 sizes average 1 percent to 1.3 percent lower than the same sizes of Gulf of Mexico white shrimp for the period 1974-1986. West coast Mexican white shrimp, on the other hand, averaged 2 percent to 9 percent higher in price than their Gulf of Mexico counterparts. These patterns do not always hold, however. During the second half of 1985 and early 1986, Ecuadorian prices were generally above the prices for Gulf whites. Vondruska does not attempt to explain these price differentials. Perhaps the handling and packing methods used in Ecuador, or the species composition, can account for the differences.

### Trends in the U.S. Shrimp Market

U.S. consumption of shrimp has grown substantially since the mid-1970s. Total consumption increased from about 450 million pounds of tails in 1976 to an estimated 635 million pounds in 1985 (see Table 18). The growth in both total and per capita consumption since 1980 is attributed to (1) recovery of the U.S. economy, (2) a strong U.S. dollar which has stimulated imports, (3) reduced availability of king and snow crab, and (4) a lack of growth in the Japanese market until 1984 (Vondruska, 1985).

According to Vodruska, the primary reason for the marked increase in U.S. shrimp imports in 1982-1983 was weakened Japanese demand. In the 1980s, the combination of lower real income growth, a weaker yen, and higher shrimp prices in Japan dampened consumer demand for shimp. However, the stronger U.S. dollar may explain much of the growth in imports and consumption in the early 1980s.

Exchange rates are known to have played a significant role in international movements of shrimp.The relative exchange rates between, say, Ecuador's sucre and the U.S. dollar and the Japanese yen can determine the destination of export shipments. While domestic supply and demand, along with preferences for certain species and sizes, play a major role in marketing decisions, the exchange rate is also a principal factor. For example, in 1980-1983, when the U.S. dollar began to appreciate faster than the Japanese yen against the Mexican peso, Mexican shrimp exports that historically were sent to Japan were instead shipped to the United States (Newman, et al., 1985).

### Japanese and European Markets

Ecuadorian exporters have not had much success entering the Japanese market. The Japanese appear to turn to Ecuador only when shrimp from their principal sources are not available. Some sources report that Japanese consumers do not like the species of white shrimp (P. vannamei and P. stylirostris) which constitutes most of Ecuador's exports (NMFS, 1981). The small amounts of shrimp regularly shipped to Japan are of deepwater red shrimp (McPadden, 1985).

Very little shrimp is shipped to Europe. A study of European markets has been commissioned, and exporters are trying to gain access to these markets. Much will depend on relative exchange rates (Spurrier, 1985).

## Credit and Finance Conditions

Access to credit to finance investment and production activities is essential for any industry. The available evidence suggests that the shrimp industry, until recently had little difficulty obtaining loans or attracting investment from abroad.

The Central Bank of Ecuador estimated loans to the shrimp industry in mid-1980 totalled U.S. $300 million. Most loans were through commercial banks. Foreign investors also have played a significant role in Ecuador's shrimp industry. U.S. investment in all segments of the industry is estimated to be U.S. $20 million to $30 million (U.S. Consulate, 1984). Table 19 lists companies with significant U.S. investment. Empacadora Shayne, one of the largest shrimp companies in Ecuador, was reported as being 50 percent owned by U.S. agribusiness entrepreneurs. Empacadora Nacional, one of the largest packers, as of 1981 was a wholly-owned subsidiary of the International Proteins Corporation of Fairfield, New Jersey. U.S. banks and importers of Ecuadorian shrimp have made loans and advance payments to shrimp farmers and packers (NMFS, 1981).

Through November 1984, low-interest government financing was available. Government interest rates were 2-3 percentage points below commercial rates. In early 1985, however, the lack of short-term credit was perceived as a serious constraint on shrimp farming operations (McPadden, 1985). During 1985, the industry had to borrow at interest rates of 25 percent or higher. By early 1986, the government had made available approximately 100 million sucres for loans to farmers to buy postlarvae (Maugle, 1986). Some sources indicate the assistance was too little and too late, and the funds were not properly applied. Hence, the credit problem was not resolved.

## Government Programs and Policies

The government of Ecuador (GOE) has implemented numerous programs and policies which directly affect the shrimp industry. Some of the programs and policies as they affect export activities, shrimp cultivation, and postlarvae production are discussed below.

### Export Activities

The system prevailing in March 1983 through August 1986 of three exchange rates (official, intervention and free) effectively works to impose an ad valorem tax of 25 percent or more on shrimp exports. The export tax credit (known as CAT) has done little to reduce the tax. One result of this policy is to induce under-invoicing of export shipments and the smuggling of shrimp to Peru (with its more favorable exchange rates and CAT). There are at least two ways to reduce or eliminate the under-invoicing and smuggling; one is to increase border monitoring and controls, and another is to reduce the effective tax on exports. The tax may be reduced by either raising the intervention exchange rate closer to the free rate or by increasing the export tax credit and making it payable immediately or with a reasonable rate of interest. The GOE in 1985 increased its monitoring of export shipments to check that invoices properly show quantity and value. Exporters are being assessed one percent of FOB to pay for this added supervision. This fee in effect adds one point to the existing export tax.

The details are not clear, but there is a law which until recently provided incentives to shrimp companies that installed a packing plant. Firms are now allowed to substitute installing hatcheries instead of packing facilities in order to qualify for incentives. Also, an additional 5 percent export tax credit is being granted to exporters using shrimp that originated in hatcheries. Such incentive policies tend to create distortions and waste in the economy as evidenced by the excess packing capacity that reportedly exists.

### Shrimp Cultivation

Perhaps the most important policy affecting shrimp cultivation is the granting of concessions for the use of land in the intertidal zone on which to build and operate shrimp farms. Above we discussed the need to extend the life of these concessions.

LiPuma and Meltzoff (1985) observe that the current policy of granting royalty-free concessions induces extensive farming methods and the destruction of an excessive amount of mangroves. A land tax or royalty would encourage more intensive farming practices, reduce the excessive destruction of mangroves, and be a relatively easy tax to administer.

### Postlarvae Production

The postlarvae shortages in 1984 and 1985 stimulated pressure on the GOE to take a variety of actions, including protecting wild stocks and assisting the development of hatcheries. We leave for others to analyze the measures taken to protect the wild stocks.

The policy to provide incentives for shrimp companies to construct hatcheries may, as stated above, introduce distortions and waste in the economy. Without more details on how the incentive policy works we cannot analyze its likely consequence in detail. There is a legitimate role (from an economics perspective) for government to engage in research and training regarding hatchery methods. However, there is not a legitimate governmental role in the production of postlarvae for commercial use. This is best left to the private sector. The available evidence does not indicate to what extent the GOE is involved in hatchery research, training and production. Therefore, we cannot evaluate these programs and policies.

There are reports that the GOE has lifted its earlier ban on the importation of postlarvae and Artemia. Usually, artificial barriers to trade are not useful and can only mitigate economic progress in the

long run. Lifting such import (as well as export) barriers is good for the industry and good for Ecuador. Barriers or controls are warranted in some cases, for example, to prevent the transmission of disease by imported postlarvae.

## The Current Situation and Outlook

In this short section we summarize the present conditions in the industry and attempt to identify a few trends likely to appear in the near future. Our discussion covers production and trade.

### Production

The cultivation sector is now the dominant source of shrimp production. Pond capacity currently exceeds the amount that can be stocked with the quantities of postlarvae available. The supply of wild postlarvae varies with environmental conditions and cannot be expected to fully supply shrimp farms' needs in the long term (except during El Nino events when they are in great abundance). Hatchery production of postlarvae must and will supply the balance. Whether hatcheries will someday produce significant quantities of postlarvae depends both on technical and economic considerations. The principal technical consideration is when and how the local industry will solve the maturation cycle. The economic considerations are whether the cost of hatchery production will be low enough (relative to price) to support large levels of postlarvae production.

When the problem of postlarvae supply is resolved, the most scarce production input may become land. What land is suitable for cultivation depends on infrastructure (e.g., access to roads) and economics (e.g., costs of pumping water), among other things. If land does become a limiting factor we can expect to observe more intensive cultivation methods adopted, to the extent that the market can support the higher costs of such methods. Offshore production of white shrimp is expected to remain at modest levels, varying as hydrographic conditions change. Little change is expected in this latter sector.

### Trade

As production expands, trade will expand. Our first concern is how the structure of the trading (export) sector can be expected to change. At present there is some degree of vertical integration, extending from production through U.S.-based import businesses. Whether we will see more or less vertical integration in the future is unclear without further study. Some government policies (e.g., the incentives law) may inadvertently encourage uneconomical vertical integration. How much concentration (the share of product marketed by a few firms) we will likely see in the future is also unknown without further investigation.

Our second concern is the future of the U.S. shrimp market. Most signs indicate a growing U.S. market over the next few years. Newman (1985) projects U.S. import demand for shrimp out to 1990. Using an econometric model, they project imports of shrimp to increase from the 1983-84 average of 342 million pounds to a range of 390-413 million pounds by 1990. This represents an expansion in import demand of from 12 percent to 17 percent. If these projections are realized, Ecuador could increase its exports to the United States to about 57 million pounds (26,000 m.t.) and retain its 14 percent share of U.S. imports. It appears that the U.S. market can comfortably absorb any reasonable increases in Ecuadorian shrimp production and exports.

Newman also attempted to project prices of imported shrimp, but could not do so reliably. However, he notes historical patterns that suggest real shrimp prices will likely rise over the period 1985 to 1990. In this analysis, he assumes real prices increase at an average annual rate of 3.5 percent, somewhat lower than the long-run trend in shrimp price increases.

Currency exchange rates are an important determinant of trade flows and of earnings by exporters and producers. Changes in exchange rates are impossible to forecast. The recent softening of the U.S. dollar against the yen and other currencies may induce more shrimp exports to Japan and Europe. The future prospects for Ecuadorian shrimp in these markets are unknown.

# Recommendations

We end with recommendations for policy changes and future research.

## Policy

1. Reduce incentives to smuggle.

Official export policies during 1983-1986 made smuggling shrimp to Peru for export very attractive and resulted in significant losses to the government of Ecuador. We recommend increasing the intervention exchange rate and/or increasing the export tax credit rate. Terms of payment of export credit should be either immediate or with an appropriate rate of interest.

2. Extend the term, or make renewal automatic, for land concessions

The current 10-year term of land concessions is likely too short, promoting inefficient use and waste. An extended term, e.g. 30 years, would provide more secure land tenure and induce more efficient use of land resources. Making renewal automatic, subject to certain reasonable conditions being fulfilled, would accomplish the same end.

## Research

1. Establish an information system and ongoing database.

Too little data currently exists on shrimp cultivation activities. The following data will be needed to properly monitor and study the industry:

(i) the number of operating firms and hectares of nursery and growout ponds of each farm
(ii) the number if hectares of ponds actually stocked throughout the year.
(iii) annual production rates of each farm
(iv) postlarvae prices, at the beach and farm

A system to collect, process and store these data should be established by government or industry.

2. Determine the costs and earnings of farms.

An in-depth survey of a representative cross-section of farms is needed. The survey should collect basic data on fixed and variable costs, sales, input quantities (postlarvae, fuel, feed, fertilizer) for a year. Information on production practices, farm size and land type also should be collected. The data and information should be analyzed to assess the profitability (or lack of) of different farm sizes, production methods, locations, etc. The results of a comprehensive, systematic costs and earnings study will indicate which types of farms are more successful, and would help guide the industry in its future growth. It will also allow industry and government to better assess future prospects for the industry.

3. Evaluate postlarvae demand.

Postlarval shrimp constitute the single most important input for shrimp cultivation. The future success of the industry depends on commercially viable hatcheries. The degree to which hatcheries will be commercially viable depends on how much postlarvae farms are likely to demand and how

much farms are willing and able to pay for postlarvae. Therefore, in conjunction with the costs and earnings study, we recommend an analysis of demand for postlarvae.

4. Evaluate international market conditions.

Since the shrimp industry is export oriented, its future fate depends on conditions in the shrimp markets of the United States, Japan and Europe. Detailed studies of each of these markets and of shrimp cultivation developments in other tropical countries (e.g., Brazil, Philippines, India) will help to keep the Ecuadorian shrimp industry abreast of long-term trends. Such information should be invaluable for guiding future investments and marketing strategies of the local industry.

5. Evaluate product quality.

Ecuadorian shrimp have commanded lower prices than their U.S. and Mexican counterparts. Is this due to quality? Can changes be made to improve quality and prices of Ecuadorian shrimp in the U.S. market? Studies to answer these questions would bring obvious benefits to Ecuador.

6. Describe and evaluate structure and organization of the industry.

The shrimp industry currently exhibits extensive vertical integration, while the degree of concentration does not appear great at present. We propose studies to investigate the following questions: What are the consequences for Ecuador of the current vertical integration, and can we expect more or less of it to occur in the future? Similarly, can we expect more or less industry concentration of production in the future and what will be the consequences? Other issues concern the extent and consequences of excess capacity and the susceptibility of the industry to boom-bust cycles.

**Table 1**
Total Shrimp Production
1954-1975

| Year | Production (m.t.) | Number of Vessels |
|---|---|---|
| 1954 | 660 | n.a. |
| 1955 | 850 | 30 |
| 1956 | 2090 | 57 |
| 1957 | 2790 | 72 |
| 1958 | 3340 | 108 |
| 1959 | 3120 | 100 |
| 1960 | 2560 | 91 |
| 1961 | 4600 | 97 |
| 1962 | 4700 | 106 |
| 1963 | 5200 | 125 |
| 1964 | 5000 | 119 |
| 1965 | 5700 | n.a. |
| 1966 | 5300 | 162 |
| 1967 | 6000 | 176 |
| 1968 | 6600 | 192 |
| 1969 | 8700 | 248 |
| 1970 | 6200 | n.a. |
| 1971 | 5900 | 276 |
| 1972 | 6800 | 246 |
| 1973 | 7800 | 255 |
| 1974 | 6500 | 266 |
| 1975 | 7500 | 247 |

Source: McPadden (1985)

**Table 2**
El Niño Events

| Years | Severity |
|---|---|
| 1958 | not known |
| 1965 | not known |
| 1969 | mild |
| 1972-73 | severe |
| 1976 | moderate |
| 1982-83 | severe |

Source: Thompson (1981)

**Table 3**
Ecuador's Exports of Shrimp
1970-1975

| Year | Volume (m.t.) | Value (million U.S.$) | FOB Prices (U.S. $) per lb | per kg |
|---|---|---|---|---|
| 1970 | 2266 | 1.7 | 0.35 | 0.77 |
| 1971 | 2941 | 4.3 | 0.67 | 1.47 |
| 1972 | 5036 | 12.9 | 1.17 | 2.57 |
| 1973 | 2839 | 9.2 | 1.47 | 3.23 |
| 1974 | 3593 | 11.4 | 1.44 | 3.17 |
| 1975 | 3754 | 14.6 | 1.77 | 3.89 |

Source; Banco Central del Ecuador (1982)

**Table 4**
U.S. Imports of Ecuadorian Shrimp
1954-1975

| Year | Quantity (m.t.) | Value (U.S. $1000) |
|---|---|---|
| 1954 | 249 | 310 |
| 1955 | 729 | 1074 |
| 1956 | 1341 | 2085 |
| 1957 | 1758 | 2873 |
| 1958 | 2017 | 3122 |
| 1959 | 2142 | 2943 |
| 1960 | 1905 | 2793 |
| 1961 | 2929 | 2986 |
| 1962 | 2328 | 4082 |
| 1963 | 2559 | 4120 |
| 1964 | 2618 | 4261 |
| 1965 | 2576 | 4427 |
| 1966 | 2381 | 4507 |
| 1967 | 2721 | 5358 |
| 1968 | 2859 | 5915 |
| 1969 | 4046 | 9164 |
| 1970 | 2724 | 5735 |
| 1971 | 3424 | 6054 |
| 1972 | 3152 | 10354 |
| 1973 | 3409 | 11174 |
| 1974 | 2823 | 11480 |
| 1975 | 3663 | 17382 |

Source: National Marine Fisheries Service

**Table 5**
Total, Trawler and Farm Shrimp Production
1976-1985

| Year | Total Production (m.t). | Trawler Production (m.t.) | Farm Production (m.t.) |
|---|---|---|---|
| 1976 | 9000 | n.a. | n.a. |
| 1977 | 8600 | n.a. | n.a. |
| 1978 | 9200 | n.a. | n.a. |
| 1979 | 12485 | 7787 | 4698 |
| 1980 | 16980 | 7800 | 9180 |
| 1981 | 20100 | 8000 | 12100 |
| 1982 | 29500 | 8000 | 21500 |
| 1983 | 44600 | 8900 | 35600 |
| 1984 | 39900 | 6300 | 33600 |
| 1985 | 36228 | 6023 | 30205 |

Sources: McPadden (1985), Direccion General de Pesca

**Table 6**
Total Areas of Shrimp Farms
1976-1986

| Year | Authorized Area[a] (cumulative; in hectares) | Area in Cultivation (estimated; in hectares) |
|---|---|---|
| 1976 | 439 | |
| 1977 | 2345 | |
| 1978 | 4178 | |
| 1979 | 6945 | 24000[b] |
| 1980 | 14707 | 30000[c] |
| 1981 | 35382 | 32000[d] |
| 1982 | 49069 | 32500[e] |
| 1983 | 62938 | |
| 1984 | 87576 | 48000[f] |
| 1985 | 94352 | |
| 1986 | n.a. | 30000[g] |

Sources: a) Direccion General de Pesca; b) Calvas (1980); c) NMFS (1981); d) Barniol (1980); e) Central Bank (1982); f) Parodi (1985); g) Maugle (1986)

**Table 7**
Areas Authorized for Shrimp Farming by Province
1976-1985

| Year | Total | | Province: Guayas | | El Oro | | Manabi | | Esmeraldas | |
|---|---|---|---|---|---|---|---|---|---|---|
| | # | ha | # | ha | # | ha | # | ha | # | ha |
| 1976 | 6 | 439 | 2 | 300 | 3 | 119 | 1 | 20 | – | – |
| 1977 | 21 | 1906 | 5 | 615 | 11 | 559 | 5 | 732 | – | – |
| 1978 | 25 | 1833 | 22 | 1766 | 1 | 15 | 2 | 52 | – | – |
| 1979 | 31 | 2767 | 15 | 1706 | 4 | 318 | 12 | 743 | – | – |
| 1980 | 73 | 7762 | 54 | 6613 | 10 | 874 | 8 | 225 | 1 | 50 |
| 1981 | 189 | 20675 | 104 | 15210 | 71 | 4379 | 11 | 630 | 3 | 456 |
| 1982 | 116 | 13687 | 40 | 10620 | 30 | 2156 | 14 | 739 | 2 | 172 |
| 1983 | 122 | 13869 | 86 | 11312 | 14 | 1326 | 17 | 859 | 5 | 372 |
| 1984 | 229 | 24638 | 157 | 20562 | 37 | 2551 | 27 | 1124 | 8 | 401 |
| 1985 | 130 | 6776 | 58 | 3504 | 26 | 2199 | 15 | 283 | 13 | 790 |
| Cumulative Total | 942 | 94352 | 573 | 72208 | 225 | 14496 | 112 | 5407 | 32 | 2241 |

Source: Direccion General de Pesca

**Table 8**
Number of Authorized Farms by Size
1984

| Area (hectares) | Total | Provinces: El Oro | Guayas | Manabi | Esmeraldas |
|---|---|---|---|---|---|
| TOTAL | 773 | 167 | 494 | 92 | 20 |
| 0-50 | 408 | 107 | 221 | 67 | 13 |
| 50-100 | 107 | 32 | 57 | 15 | 3 |
| 100-200 | 141 | 15 | 116 | 7 | 3 |
| 200-300 | 92 | 11 | 77 | 3 | 1 |
| 300-500 | 13 | 1 | 12 | – | -- |
| 500-700 | 7 | 1 | 6 | – | -- |
| 700-1000 | 4 | – | 6 | – | -- |
| 1000-more | 1 | - | 1 | – | -- |

Source: McPadden (1985)

**Table 9**
Costs and Earnings, 1979-1981 (sucres per pound)

| PROVINCE | 1979 | 1980 | 1981 |
|---|---|---|---|
| | | Average Costs of Production | |
| Guayas | 46.25 | 48.33 | 35.62 |
| El Oro | 36.23 | 36.00 | 34.19 |
| Manabi | 30.00 | 30.17 | 30.78 |
| Esmeraldas | -- | -- | -- |
| TOTAL | 37.49 | 38.16 | 33.53 |
| | | Average Price | |
| Guayas | 96.50 | 64.83 | 59.15 |
| El Oro | 63.00 | 64.04 | 61.25 |
| Manabi | 71.00 | 63.78 | 58.89 |
| Esmeraldas | 76.80 | 64.20 | 59.80 |
| TOTAL | 76.80 | 64.20 | 59.80 |
| | | Gross Margins | |
| Guayas | 50.25 | 16.50 | 23.53 |
| El Oro | 26.77 | 28.04 | 27.07 |
| Manabi | 41.00 | 33.61 | 28.11 |
| AVERAGE | 39.30 | 26.10 | 26.20 |

Source: Banco Central del Ecuador

**Table 10**
Estimated Postlarval Use

| Year | Estimated Hectares in Cultivation | Estimated Number of Postlarval Required for Stocking (in billions) NMFS Method*[a] | Other Sources |
|---|---|---|---|
| 1979 | 24,000[b] | 5.3 | |
| 1980 | 30,000[c] | 6.6 | 4-6[c] |
| 1981 | 32,000[d] | 7.0 | 3.6-4.8[d] |
| 1982 | 32,500[e] | 7.2 | |
| 1983 | | | 9.0[f] |
| 1984 | 48,000[g] | 10.6 | |
| 1985 | | | |
| 1986 | 30,000[h] | 6.6 | |

Sources: a) NMFS, 1985b; b) Calvas, 1980; c) NMFS, 1981; d) Barniol, 1980; e) Central Banks, 1982; f) McPadden, 1984: g) Parodi, 1985; h) Maugle, 1986.

* The NMFS (1985b) method assumes (i) an average stocking density of 50,000 postlarvae/hectare/crop, (ii) a postlarvae survival rate of 50 percent, and (iii) an annual average of 2.2 crops.

**Table 11**
Postlarvae Prices (Sucres/1,000)

| Date | Beach Price | Farm Price | Estimated Real Farm Price (1979 sucres) |
|---|---|---|---|
| 1980 | | 75-100[a] | 60-180 |
| 2/84 | | 450-540[b] | 160-190 |
| 2/85 | 100[e] | 400-600[c] | 110-165 |
| 5/7/85 | | 1300[c] | 330 |
| 8/9/85 | | 1800[d] | 440 |
| 10/11/85 | | 1500[d] | 365 |
| 12/85-1/86 | | 1200[d] | 285 |
| 2/3/86 | | 500[d] | 120 |
| 3/86 | | 700-800 | |

Sources: a) Calvas, 1980; NMFS, 1981; b) NMFS, 1984; c) McPadden 1985; d) Leslie, 1986; e) Maugle, 1986.

**Table 12**
Hatchery Costs

| Investment Hatchery | Investment Cost (U.S. dollars) | Expected Production (10 PL/hr) | Production Costs (per 1000 PL) (sucres) | Minimum Average Price Required* (sucres) |
|---|---|---|---|---|
| High tech, Large | 2-2.5 million | 300 | 500-800 | 1,090 |
| High tech, Small to med. | 250-800 thousand | 60-120 | 400-600 | 835 |
| Japanese tech, Large | 1 million | 200 | 300-500 | 675 |
| Japanese "Bamboo" | 30-100 | 12-40 | 250-400 | 490 |

Source: Leslie, 1986.

* Calculated using the formula $Kxi < (P-C) \times Q$, where K is capital investment costs, i is the rate of interest (assumed .25), P is the average price, C is production cost per 1,000 postlarvae, and Q is expected production rate. For this calculation, we used the upper values of the ranges given for K, Q and C. The exchange rate used is S/140 = $1.00.

**Table 13**
Areas of Authorized Shrimp Farms by Land Type, 1983-1985

| | Intertidal Land | High Land | Total |
|---|---|---|---|
| 1983 | 27,400 | 33,000 | 60,400 |
| 1985 | 36,500 | 57,900 | 94,400 |

Sources: 1983 from McPadden (1985; from Direccion General de Pesca).

**Table 14**
Exports of Shrimp

| Year | Quantity (m.t.) | Value (million U.S.$) |
|---|---|---|
| 1976 | 4,768 | 24.6 |
| 1977 | 4,364 | 25.6 |
| 1978 | 4,288 | 24.0 |
| 1979 | 4,043 | 31.0 |
| 1980 | 9,674 | 66.4 |
| 1981 | 12,133 | 83.9 |
| 1982 | 16,966 | 130.0 |
| 1983 | 23,534 | 184.7 |
| 1984 | 20,339 | 154.2 |
| 1985 | 19,799 | 155.7 |

Sources: 1976-1979, Banco Central (1982); 1980-1985, Direccion de Pesca).

**Table 15**
Estimated Exporters[1] Sales

| Year | Sales[a] (billions of current sucres) | Adjusted Sales[b] (billions of 1978/79 sucres) |
|---|---|---|
| 1981 | 2.08 | 1.52 |
| 1982 | 4.29 | 2.79 |
| 1983 | 15.85 | 6.80 |
| 1984 | 13.64 | 4.49 |
| 1985 | 14.79 | 3.73 |

[a] U.S. dollar value of exports multiplied by the official exchange rate for 1981 and 1982, and by the intervention exchange rate for 1983-1985.
[b] Sales divided by the consumer price index, May 1978/April 1979 = 100.

**Table 16**
Export Prices, FOB, 1976-1985

| Year | FOB Price per pound[a] (U.S.$) | Estimated Exporters' Price[b] (sucres per lb) | Adjusted Exporters Price (1978-79 sucres) |
|---|---|---|---|
| 1976 | 2.34 | | |
| 1977 | 2.66 | | |
| 1978 | 2.55 | | |
| 1979 | 3.48 | | |
| 1980 | 3.11 | | |
| 1981 | 3.14 | 78[d] | 57 |
| 1982 | 3.47 | 115 | 75 |
| 1983 | 3.58 | 307 | 132 |
| 1984 | 3.44 | 304 | 100 |
| 1985 | 3.58 | 340 | 86 |

[a] Sources: 1976-1979, Banco Central (1982); 1980-1985, Direccion de Pesca

[b] U.S. dollar value of exports multiplied by the official exchange rate for 1981 and 1982, and by the intervention exchange rate for 1983-1985.

[c] Sales divided by the consumer price index, May 1978/April 1979 = 100.

[d] Average farm price was about 60 sucres/lb (Central Bank, 1982).

**Table 17**
U.S. Imports of Ecuadorian Shrimp, 1976-1985

| Year | Quantity (m.t.) | Value (U.S. $1000) |
|---|---|---|
| 1976 | 4,252 | 25,627 |
| 1977 | 3,915 | 23,996 |
| 1978 | 4,975 | 30,033 |
| 1979 | 6,229 | 54,483 |
| 1980 | 9,180 | 68,081 |
| 1981 | 11,243 | 80,303 |
| 1982 | 16,417 | 136,509 |
| 1983 | 23,349 | 218,729 |
| 1984 | 21,183 | 185,548 |
| 1985 | 19,964 | 166,087 |

Source: NMFS

**Table 18**
U.S. Consumption of Shrimp, 1976-1985
(1,000 lbs, heads-off equivalent, and lbs per capital)

| Year | Consumption | |
|---|---|---|
| | Total | Per Capita |
| 1976 | 447630 | 2.073 |
| 1977 | 480082 | 2.201 |
| 1978 | 460082 | 2.087 |
| 1979 | 399810 | 1.793 |
| 1980 | 435788 | 1.932 |
| 1981 | 447236 | 1.964 |
| 1982 | 464476 | 2.020 |
| 1983 | 526527 | 2.274 |
| 1984 | 593852 | 2.533 |
| 1985 | 625000E | 2.690 |

Data for 1978-1985 subject to revision
E: Landings, total supply, and consumption estimated for 1985. Prepared by John Vondruska, February 7, 1986.

**Table 19**
U.S. Investment in the Shrimp Industry

| Ecuadorian Company | Areas of Activity | U.S. Investor |
|---|---|---|
| Empacadora Nacional | Shrimp boats<br>Packing plant<br>Hatchery<br>Farm production | International Protein Corp. Fairfield, NJ |
| Acuespecies S.A. | Farm production | Amorient Aquaculture Int'l, Laguna Niguel, CA |
| Langostinos S.A. | Farm production | Castel and Cooke, San Francisco, CA |
| Frescamar S.A. | Packing plant<br>Hatchery<br>Farm production<br>Feed mill | Morrison Grain Company Salinas, KS |
| Molinos Champion | Farm production<br>Feed mill | Continental Milling Corporation New York, NY |

Source: Parodi (1985)

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