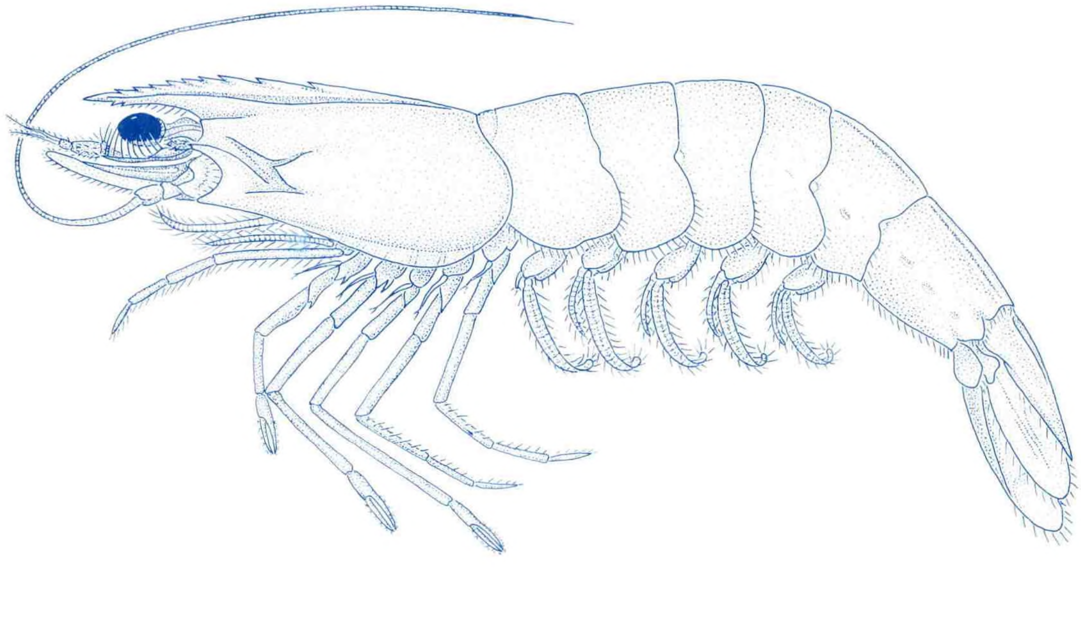
World Shrimp Culture

Volume 2, Part Two

Central America



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World Shrimp Culture

Volume 2: Latin America

Prepared by
The Office of International Affairs

Dennis Weidner
Tom Revord
Randy Wells
Amir Manuar

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Prepared by:

The Office of International Affairs, F/IA2
National Marine Fisheries Service, NOAA
U.S. Department of Commerce
1335 East-West Highway,
Silver Spring, MD 20910
U.S.A.

Tel: 301-713-2286
Fax: 301-713-2313

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CENTRAL AMERICA

Central American countries, including Mexico, are reporting progress in developing an important shrimp culture industry. Commercial operations are underway in every country, almost exclusively with Pacific white shrimp, *Penaeus vannamei* and to a lesser extent *P. stylirostris*. Growers have experimented with Ecuadorean-style extensive growout systems, but are increasingly turning to higher yielding semi-intensive systems. Most successful growers rely primarily on wild-collected seedstock, but production of hatchery seedstock is expanding. The most important hatchery industry has developed in Panama and hatcheries there are developing a major export trade in postlarvae and nauplii. The Mexican/Central American harvest is still a small part of the overall South American harvest. The progress being reported in several countries (Guatemala, Honduras, Mexico, Nicaragua, and Panama), however, has enabled growers to report steadily expanding harvests during the 1980s. Growers increased harvests from minor amounts in 1980 to nearly 13,000 t in 1989. They are reporting continued expansion in the early 1990s and harvests almost exceeded 20,000 t in 1991. Further increases are likely in 1992, primarily because of the expanding Honduran and Mexican harvest, but smaller increases are likely in each country. Two countries (Honduras and Mexico) are likely to report very substantial progress during the 1990s and should be harvesting substantial quantities of shrimp by the year. 2000. Other countries (Nicaragua and Panama) have the potential to approach Honduran catch levels, but a variety of economic and political constraints have limited development. Other countries (Belize, Costa Rica, El Salvador, and Guatemala) will probably develop smaller industries, but of some local importance.

I. CAPTURE FISHERIES

The shrimp fisheries of Central America and Mexico[1] are the most important commercial fisheries in almost every country. Mexico conducts the largest shrimp fishery in the region and catches during the 1980s ranged from 72,000-84,000 metric tons (t). The Central American countries report substantially lower catches, but the combined total of all seven countries is considerable, about 25,000-30,000 tons. Each of the Central American countries (except Belize) have shrimp fisheries which are of considerable importance to the local economy. Many of these fisheries, however, are experiencing economic difficulties because of declining catches, falling prices, operating cost increases, and a variety of other factors. The largest Central American shrimp fishery is conducted by Panama which is an important U.S. supplier. Costa Rica accounts for substantial catches, although available catch data is somewhat confusing. The Nicaraguan shrimp fishery has declined sharply since the early 1980s because of Sandinista mismanagement and, as a result, current catches are not an accurate reflection of the potential resource. Nicaraguan stocks could support significantly expanded fishing effort. Smaller, but still important fisheries are conducted in Honduras, El Salvador, and Guatemala.

Shrimp fisheries are conducted along both Caribbean (Belize, Honduras, Mexico, and Nicaragua) and Pacific Coasts (Costa Rica, Guatemala, Mexico, Nicaragua, Panama, and El Salvador). Several countries have Pacific-coast stocks of *P. stylirostris* and *P. vannamei*. Growers thus have access to wild supplies of postlarval seedstock suitable for pond culture. This has proven of great advantage to the developing industry. Even in Honduras where little shrimp is caught along the country's small Pacific (Gulf of Fonseca) coast, pl can be collected to supply the growers. Growers have also benefitted from the established processing industry servicing the trawler fishermen.

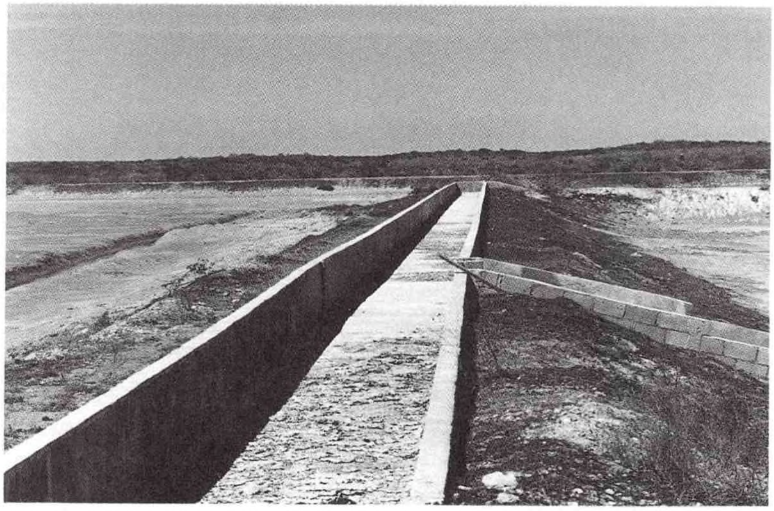

Photo 1.--Mexico has the potential for a significant shrimp culture industry. Many farms, like this Gulf of Mexico farm, however, report continuing problems.
Dennis Weidner

II. AQUACULTURE

Mexico and Central America are just beginning to develop aquaculture industries. Mexico reports a small industry, focusing primarily on bivalve mollusks. The Mexican harvest totaled about 60,000 t in 1989 (appendix B).[2] The Central American countries, however, have not yet developed significant aquaculture industries. None of the Central American counties reported an aquaculture harvest exceeding 4,000 t (appendix B), and in most cases a substantial part of the reported harvest was shrimp. Because these countries have not yet developed a significant aquaculture industry, beginning shrimp growers in the early 1980s, did not have an infrastructure base to draw upon.

The small size of the Central American countries means that the domestic aquaculture training and research capability is very limited. Nor have the countries involved made an effort to initiate a Central American-wide training and research program. The Organización Latinoamericano para el Desarrollo Pesquero (OLDEPESCA) assistance program is administering a regional fisheries project in Central America, the Programa Regional de Apoyo al Desarrollo de la Pesca (PRADEPESCA) which include shrimp culture projects. PRADEPESCA includes a regional marine and freshwater shrimp culture project involving both hatchery and growout work.[3] The program, however, primarily operates through national agencies focused on national development. The limited aquaculture training and research effort underway in Central America has greatly complicated the growers' ability to hire experienced technicians and obtain consulting services, equipment, feed, chemicals, etc.

The legal framework has created other problems for growers in several countries. Existing fishery laws and land/water management regimes were prepared before aquaculture developed as a recognized commercial activity. As a result, the legal structure in force during the 1970s-80s did not address the complexites associated with aquaculture development. In several countries this has complicated administrative processes and the countries in the region are just beginning to make necessary structural changes.

III. SHRIMP CULTURE

Mexico and the seven Central American countries (Belize, Costa Rica, El Salvador, Guatemala, Honduras, Panama, and Nicaragua) have the potential to develop a significant shrimp culture industry. Mexico and each Central American country have substantial areas with suitable conditions for farm sites. The potential Mexican area may total 350,000 ha, but precise estimates are unavailable.[4] Even if the northern, more temperate states are excluded, Mexico clearly has a very substantial area suitable for shrimp culture. Mexican growers, however, have built only about 7,000 ha of ponds.[5] While each Central American country alone has a limited potential, the regional total is significant. One source estimates that suitable sites in Central America (excluding Mexico) probably exceed 100,000 ha, only slightly less than the current pond area in Ecuador.[6] Clearly the potential exists in the region for a very substantial industry and local growers are just beginning to develop that potential. The authors estimate that actual constructed pond area in 1991 totaled only about 12,000 hectares, most of which is located in just two countries (Honduras and Panama).[7]

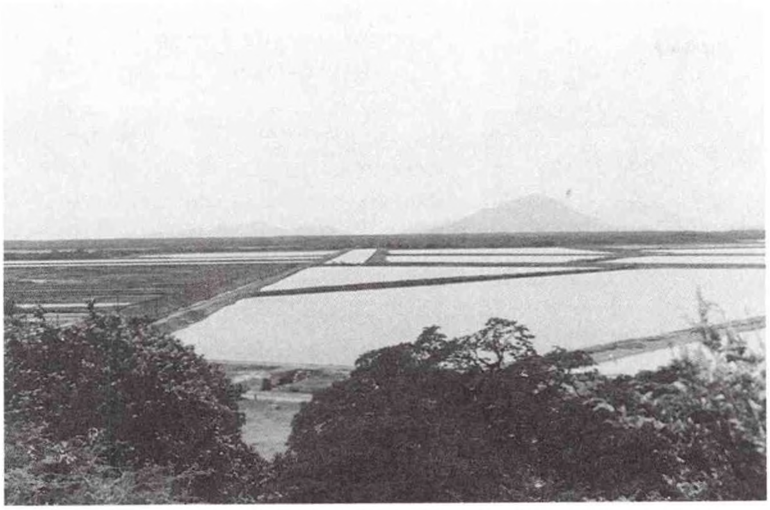

Photo 2.--Honduran growers, like CULCAMAR near Choluteca, are emerging as regional leaders. © *Jorge Pang, Agromarina*

Investors launched commercial projects during the 1980s with varying degrees of success. With the exception of Belize, almost all of the Mexican/Central American farms are currently located along the Pacific coast. Mexico has reported some very substantial harvest increases and the Government reports marine harvests approaching 7,000 tons.[8] Several companies, however, are achieving lower yields than they anticipated and are, as a result, experiencing financial difficulties. Several Central American countries (Guatemala, Honduras, and Panama) have succeeded in developing small but promising shrimp culture industries, but the other countries have encountered a variety of problems which they have not yet resolved. Honduras has become the Central American leader, harvesting about 4,500 t in 1991. Panama which for several years was the only Central American country reporting a significant harvest has made little progress in further expanding the harvest in recent years. Guatemala reports a small, but growing harvest by some particularly well managed farms. The other countries (Belize, Costa Rica, Nicaragua, and El Salvador) all have potential, but are experiencing a variety of startup problems.

Mexican and Central American growers have tried a variety of methods ranging from primitive estuarine enclosures (Mexico and Nicaragua) to modern intensive farms (Guatemala). Most growers have concluded that the most profitable approach is semi-intensive farming. Individual growers in some countries are reporting quite impressive yields, although the range of yields suggests that the industry would benefit from consulting services.

Central American growers report a variety of problems. Difficulties include climatic limitations, unfavorable domestic legislation, lack of government support, limited technical background, shortage of trained personnel, poor site selection, obtaining pl (especially along the Caribbean coast), disease outbreaks, civil disorders, and political instability. These problems have discouraged the industry's development in several countries (Belize, Costa Rica, Mexico, Nicaragua, and El Salvador). Several of these countries, however, have notable potential.

Temperatures: Temperatures are a major factor because the species being cultured are tropical shrimp. The temperature factor is an especially serious constraint in Mexico. The country extends from about 32°-14° N, encompassing both temperate and subtropical climates. Central America on the other hand extends from 18°-10° N encompassing subtropical and tropical climates. Mexico is the leading country in the region, with a larger potential area than all of Central America combined. Substantial areas of Mexico, however, are located in northern latitudes where the climate is less favorable than in Central America.

Precipitation: Precipitation and the availability of freshwater is another key factor. Arid conditions, especially in northern Mexico, adversely affect yields. Mexico and Central America also experience a disruptive Pacific dry season. Central American countries experience a dry season from November to April and a rainy season from May to October, although some variations exist between the different countries. During the dry season, there is less water available to flush the estuaries and to circulate in ponds. Evaportation rates increase. The deteriorating water quality and elevated salinities can cause serious pond management problems. Growers report that harvests decline and feed conversion ratios can increase during the dry season. Farm managers also experience problems during the rainy season when it can be difficult to adequately dry and prepare pond bottom before restocking.[9]

share of the actual pl production, however, has come from Panama. An expanded hatchery industry will be necessary for the continued growth of the industry, especially the utilization of Caribbean-coast sites. As the hatchery industry develops, the importance of access during the 1980s to wild pl stocks may decline. Once Caribbean-coast growers obtain adequate seedstock supplies, greatly expanded development along the Caribbean-coast is likely.[11]

Government policy: The industry's development throughout Central America has been impaired by macroeconomic policies on investment, interest rates, foreign investment, profit repatriation, import policies, and a host of other regulations. Political instability in several countries (El Salvador, Guatemala, Nicaragua, and Guatemala) has acted to discourage private sector development. The industry's development in Mexico, for example, was severely impeded during the 1980s by laws reserving marine shrimp culture to cooperatives.[12] As a result, the industry in Mexico lagged behind countries with much less potential. The successes reported in Central America have been mainly in countries (especially Guatemala, Honduras, and Panama) which have allowed private investors to enter the industry. Foreign investors have played an especially prominent role and most of the larger farms have varying degrees of foreign investment and/or technical assistance. Recent Government changes in several countries (Mexico, Nicaragua, and Panama) have brought to power a generation of leaders more committed to democracy and free market economics.

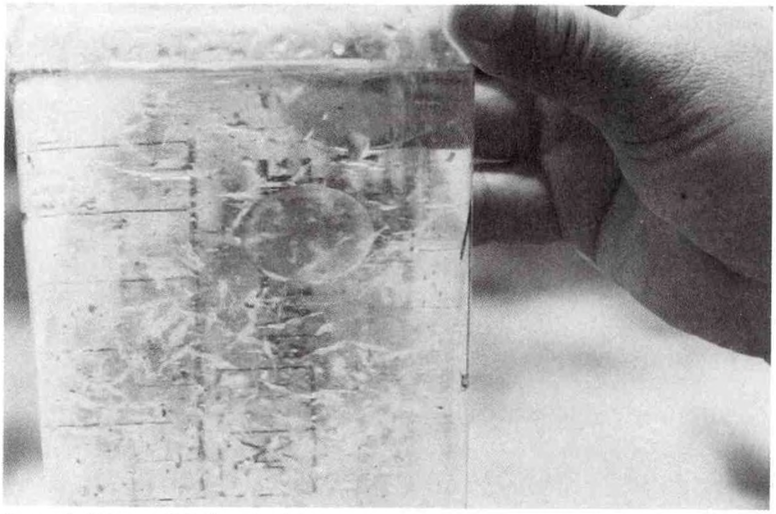

Photo 3.*--The availability of wild seedstock has been a tremendous advantage to Pacific-coast growers. © Jorge Pang, Agromarina*

Coasts: The industry is currently limited almost entirely to the Pacific coast where growers can obtain wild seedstock. Mexico and most of the Central American countries (except Belize and El Salvador) have both Pacific and Caribbean coasts. Even those countries which have both Pacific and Caribbean coasts, however, have successful shrimp farms only along their Pacific coast. Many insist that shrimp growout can be successfully conducted along the Atlantic coast.[10] Few farms have even been built along the Caribbean. Some Mexican growers are reportedly active in the northern Gulf of Mexico state of Tamaulipas and several Belizean growers are active. Neither of these countries, however, have yet achieved substantial results along the Atlantic/Caribbean coast.

Seedstock: The success of Pacific-coast growers is due, at least in part, to the availability of wild *P. vannamei* pl to stock ponds. The limited number of hatcheries in Central America and Mexico keeps most countries dependent on pl seedstock collected in the wild. Even in Honduras, a country with an important Caribbean-coast shrimp fishery and only a few kilometers (km) of Pacific coast, the industry has developed almost entirely along the Pacific coast. The initial Mexican/Central American development has relied on collection of wild pl seedstock. About 40 hatcheries have been built in Mexico and Central America (appendix D). Most of the hatcheries are in Mexico. A large

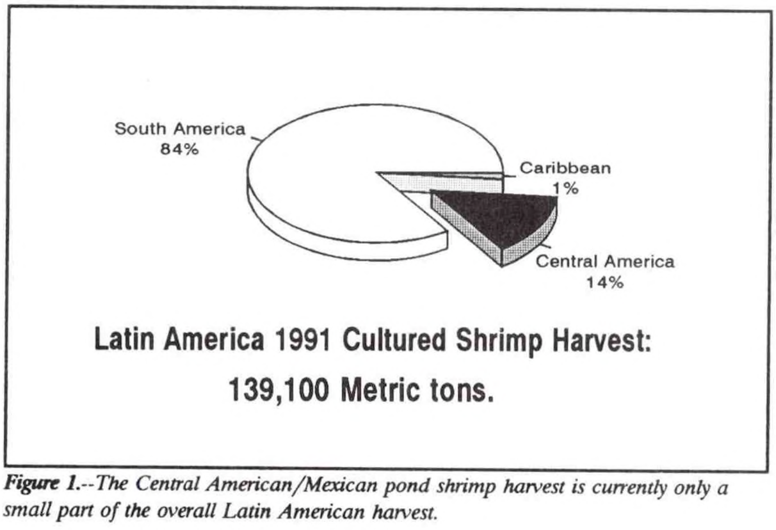

Figure 1.*--The Central American/Mexican pond shrimp harvest is currently only a small part of the overall Latin American harvest.*

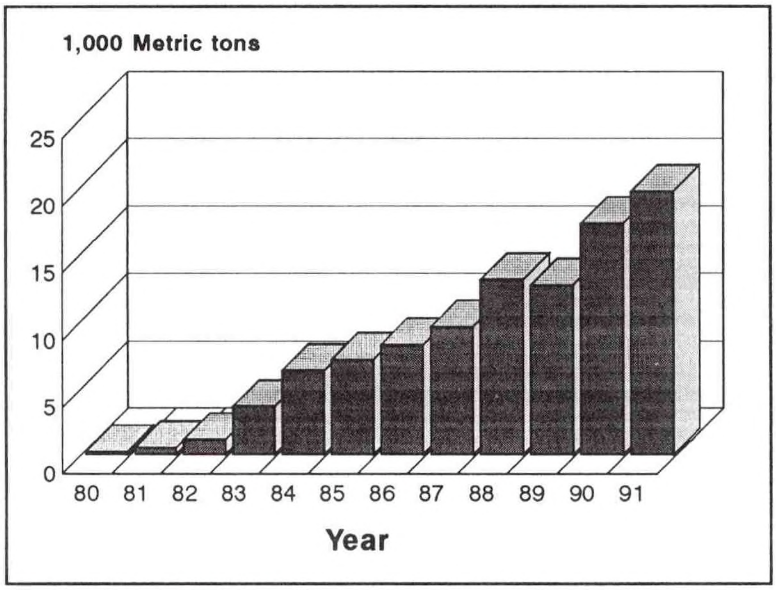

Figure 2.--Central American and Mexican growers are steadily expanding cultured shrimp harvests.

Central American countries are reporting progress in developing a shrimp culture industry. The Mexican/Central American harvest is still a small part of the overall South American harvest (figure 1). The progress being reported in several countries (Guatemala, Honduras, Mexico, Nicaragua, and Panama), however, has enabled growers to report steadily expanding harvests during the 1980s (figure 2). Growers increased harvests from minor amounts in 1980 to nearly 13,000 t in 1989. Growers are reporting continued expansion in the early 1990s and harvests almost exceeded 20,000 t in 1991 (appendix C). Further increases are likely in 1992, primarily because of the expanding Honduran and Mexican harvest, but smaller increases are likely in each country. Two countries (Honduras and Mexico) are likely to report very substantial progress during the 1990s and should be harvesting substantial quantities of shrimp by the year 2000. Other countries (Nicaragua and Panama) have the potential to approach Honduran catch levels, but a variety of economic and political constraints have limited development. Several countries (Belize, Costa Rica, El Salvador, and Guatemala) will probably develop small industries, but of some local importance.

The Honduran Federation of Agricultural Producers and Exporters (FPX) and the Honduran National Aquaculture Association (ANDAH) organized the "Central American Symposium on Shrimp Farming". The Symposium was held in Tegucigalpa, April 24-26, 1991. The program included a presentation by each Central American country on the status of the shrimp culture industry, conferences on a variety of technical and administrative topics, meetings to introduce new products and services, and working groups to discuss technical themes of interest to Central American producers. U.S. AID and OLDEPESCA sponsored the symposium. The Federación de Productores y Exportadores y Agroindustriales de Honduras sponsored a followup session focusing more heavily on financing, "Encuentro Internacional Técnico Bancario Sobre Camarón Cultivado," during April 22, 1992, in Tegucigalpa, Honduras.

Photo 4.--Honduran growers have built some of the largest farms in Central America. © Jorge Pang, Agromarina

SOURCES

Aizprua, Julio César. "Paises centroamericanos valorizan sector pesquero," *La Prensa*, September 12, 1991 and OLDEPESCA, "Programa Regional de Apoyo al Desarrollo de la Pesca en el Istmo Centroamericano: Plan de trabajo, Primer Año de Operaciones," July 9, 1991.

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Rosenberry, Robert. "Shrimp Farming in Central America," *World Shrimp Farming*, July 1991, pp. 2-11.

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Wells, Randolf, and Dennis Weidner. "Mexican Shrimp Culture," *International Fishery Reports*, (IFR-92/27), March 31, 1992.

ENDNOTES

SECTION I (Capture Fisheries)

1. Mexico which is actually part of North America is treated with the Central American countries because conditions in southern Mexico are similar to Central America and for organizational simplicity.

SECTION II (Aquaculture)

2. Mexican statistics report a higher harvest because the Government classifies freshwater fisheries targeting stocked populations (primarily tilapia) as aquaculture.

3. The program is partially financed by the European Community. Julio César Aizprua, "Paises centroamericanos valorizan sector pesquero," *La Prensa*, September 12, 1991 and OLDEPESCA, "Programa Regional de Apoyo al Desarrollo de la Pesca en el Istmo Centroamericano: Plan de trabajo, Primer Año de Operaciones," July 9, 1991.

SECTION III (Shrimp Culture)

4. Available estimates range from 350,000 - 815,000 hectares. None of these estimates, however, are based on detailed site inspections. They include large areas in northern Mexico which may eventually prove unsuitable because of the relatively temperate climate. They also include the Caribbean coast which Mexican growers will have difficulty developing until they resolve their pl supply problem. For details on available Mexican estimates see Randolf Wells and Dennis Weidner, "Mexican Shrimp Culture," *International Fishery Reports*, (IFR-92/27), March 31, 1992.

5. The authors have also noted a wide range of estimates on actual pond area, varying from about 5,000-11,000 hectares.

6. One group estimates about 120,000 hectares. OLDEPESCA, "Informe Final. Acuerdo de Cooperación: Preparación de Proyectos Regionales (OLDEPESCA/CEE), 1991, p. 25. Available estimates of potential sites are difficult to evaluate because they were prepared by different groups, often using varying criteria. In addition, many country estimates do not include potential Caribbean sites because the industry has not yet begun to develop there. Using the more optimistic estimates and including provision for potential Caribbean-coast development, the area of potential Central American sites could reach 200,000 hectares.

7. One report estimated that as of 1990, about 13,000 ha of ponds had been constructed. OLDEPESCA, *op. cit.*

8. The estimates of 7,000 t were made by SEPESCA officials and published in Mexican newspapers. Official SEPESCA statistics, however, suggest a smaller harvest of about 5,000 tons. Dirección General de Informatica y Registro Pesqueros, unpublished data received July 14, 1992. The authors are unable to explain the statistical discrepancy.

9. Robert Rosenberry, "Shrimp Farming in Central America," *World Shrimp Farming*, July 1991, pp. 2-11.

10. Observers point to the highly successful Colombian farms along that country's Caribbean coast.

11. Development along the Caribbean in several countries (Costa Rica, Nicaragua, and Panama) is likely to be slowed by a variety of other problems, such as the very limited infrastructure in some areas. The major factor, however, has probably been the problems obtaining seedstock.

12. Dennis Weidner and Randolf Wells, "Mexican Shrimp Culture: Legal Changes," *International Fishery Reports*, (IFR-91/22), March 31, 1991.

APPENDICES

Appendix A.--Central America. Total shrimp harvests by region and country, 1980-91.

Country	Year											
	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	1,000 Metric tons*											
Mexico	77.6	72.0	78.7	78.9	76.1	74.6	73.2	83.9	73.2	74.8	62.3	NA
Panama	10.5	15.3	14.7	14.2	11.8	18.4	16.1	10.6	9.5	13.4	9.0	NA
Costa Rica	3.5	4.6	4.5	2.7	4.4	8.7	8.7	8.8	8.9	8.9	9.0	NA
Honduras	2.6	3.1	2.7	3.3	3.6	3.8	5.8	5.2	7.5	4.2	5.0	NA
El Salvador	0.8	3.2	3.2	2.4	6.8	2.9	3.4	2.9	3.2	3.6	3.6	NA
Guatemala	2.2	2.8	2.5	1.6	2.3	1.9	1.3	1.1	1.6	2.2	2.6	NA
Nicaragua	4.1	3.5	2.7	1.5	1.6	1.7	1.0	1.1	1.4	1.3	1.0	NA
Belize	0.1	Negl	Negl	Negl	Negl	0.1	0.3	0.3	0.3	0.8	0.3	NA
Total	101.4	104.5	109.0	104.6	106.6	112.1	109.8	113.9	105.6	109.2	92.8	NA

* - Liveweight equivalent
NA - Not Available
Negl - Negligible
Source: FAO, Fishery Statistics Yearbook, various issues.

Appendix B.--Central America. Cultured fish and shellfish harvests,* 1985-89

Region/Country	Year				
	1985	1986	1987	1988	1989
	1,000 Metric tons				
Mexico**	49.7	47.4	59.2	60.8R	60.8R
Panama	5.4	3.5	3.5	4.3F	3.7F
Honduras	0.5	1.0	2.0	2.8	1.6
Guatemala	0.5	0.5	0.7	0.9R	1.0F
El Salvador	0.7	0.8	0.8	0.7	0.7
Belize	Negl	Negl	0.2F	0.4F	0.4F
Costa Rica	0.1	0.1	0.3	0.4	0.4
Nicaragua	Negl	Negl	0.1	0.1	0.1F
Total	56.9F	53.3F	66.8F	70.4F	68.7F

* Excludes seaweed.
** Mostly mollusks.
F - FAO estimate
R - Derived from the repetition of data previously reported by the country
Source: FAO, "Aquaculture Production (1986-89)," FAO Fisheries Circular No. 815, Rev. 3, July 1991 and previous issues.

Appendix C.--Central America. Shrimp culture harvests, 1980-1991

Country	Year											
	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991*
	1,000 Metric tons											
Mexico♦	0.1	Negl	0.1	2.4	3.9	3.4	3.3	4.0	6.1	4.7	7.8	9.2
Honduras	NA	0.1	0.2	0.3	0.5	0.6	1.3	1.9	2.4	3.2	3.2	4.5
Panama	NA	NA	0.8	0.8	1.5	2.6	3.0	2.8	3.5	3.5	3.5E	2.7E
Guatemala	-	-	Negl	0.1	0.3	0.5	0.6	0.8	0.8	0.8	1.8	2.4E
Costa Rica	-	-	-	-	-	Negl	Negl	Negl	0.1	0.1	0.4	0.6
Nicaragua	-	-	-	Negl	NA	NA	NA	Negl	0.1	0.1	0.2	NA
Belize	-	-	-	-	-	NA	NA	Negl	Negl	0.1	0.2	NA
El Salvador♦	NA	NA	NA	NA	NA	NA	Negl	Negl	Negl	0.1	0.1	0.1
Total	0.2E	0.5E	1.1	3.6	6.3	7.1	8.2	9.5	13.0	12.6	17.2	19.6

E - Estimated
♦ All or a substantial portion of the harvest is or has been freshwater shrimp. For details see the individual country studies prepared by NMFS.
* 1990 harvest data was used when 1991 data was not available to compute an approximate 1991 harvest.
Sources: Various country sources.

Appendix D.--Central America. Shrimp culture industry overview, 1991*

Region/Country	Proportion cultured	Harvest	Ponds**	Yield	Hatcheries	Farms	Comment
	Percent	Metric tons	Hectares	Tons/ha	Number		
Belize	70	200E	570	1.0	2	4	Spotty performance
Costa Rica	5	600	500	1.1	-	4	Limited progress
El Salvador♦	10	135	125	1.1	3	6	Limited area
Guatemala	50	2,400	770	1.0	-	14	Some potential
Honduras	70	4,500	6,008	0.9	2#	80•	Consistent producer
Mexico	15	6,700***	7,000E	0.9	21	140	Major expansion underway
Nicaragua	50+	200	185@	0.4	-	5@@	Great investor interest
Panama	30	2,700E	4,200	1.0	9	45	Hatchery industry
Total	NA	17,435	19,358	NA	37	298	

E - Estimated
NA - Not available/applicable
* Virtually all the 1991 figures are preliminary estimates. Data for 1989 or 1990 has been used if 1991 estimates were unavailable.
** Ponds in production, but available reports often do not differentiate between pond area constructed and in operation.
*** Excludes sizeable freshwater harvest. No data is available for 1991, but Mexican statistics suggest that freshwater harvests can reach 3,000 tons. Mexican statistics, however, often combine aquaculture and freshwater catches. Some sources suggest the 1991 marine harvest was only about 4,500 tons.
• Only 25 of these farms are modern semi-intensive operations. The rest are primarily small artisanal or extensive operations using salt evaporation ponds to produce shrimp during the rainy season.
♦ 1990 data
\# Small scale hatcheries.
\+ This high ratio is due to the decline of the trawler fishery rather than expansion of pond harvests.
@ Does not include 600 ha of estuarine enclosures and 400 ha of salt evaporation ponds.
@@ Available data on Nicaragua is incomplete, several additional farms may exist. The Government has reportedly received numerous applications from investment groups.
Source: Various country reports.

3.1

BELIZE

Belize is developing a small shrimp culture industry. Observers report that the country has several attributes which make it an excellent location to culture shrimp, including a stable government, an effective Government support program for the industry, a semi-tropical climate allowing year-round operations, and close proximity to U.S. and Caribbean markets. Although the industry seems to have many advantages, its development has been limited and harvests remain small--only about 220 metric tons in 1991. The industry's growth has been impaired by several factors. First, Belize does not have an indigenous species that has proven suitable for pond culture. This has forced growers to make costly investments in hatcheries and to import seedstock from foreign suppliers. Second, the failure of several large operations has made it more difficult for growers to attract investment capital. Despite the limited results achieved, considerable interest exists in the industry. One grower is now reporting considerable success. Modest harvest increases are likely during the 1990s.

CONTENTS

I. CAPTURE FISHERY

Belize has not developed a significant capture shrimp fishery. The country's fishermen mainly target lobster, conch, and assorted finfish. Shrimp catches until 1986 did not exceed 60 metric tons (t), and dropped as low as 2 t in 1984. The Belizean Fishermen's Cooperative Federation, in conjunction with the Government Fisheries Unit (FU), established joint shrimp ventures in 1985 in order to more fully exploit the shrimp fishery. The primary partners for joint-venture operations have been Honduran fishermen. Since 1985 about 10 different Honduran trawlers have been contracted by 4 Belizean cooperatives. Foreign fishermen are required to hire at least some Belizean crew members. The FU also issued new shrimp fishing regulations in 1985. Since the joint venture program was initiated in 1985, shrimp catches have increased somewhat, but are still only a fraction of those reported elsewhere in Central America. Belize reported shrimp catches averaging about 200 t between 1986-90 (appendix A).[1]

II. POND AREA

The potential area suitable for development is unknown. The constructed pond area increased steadily from 440 hectares (ha) in 1987 to over 930 ha in 1991. The portion of ponds actually in operation, however, is now quite low. While the operating pond area increased from only 380 ha in 1987 to almost 700

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ha in 1989, several farms closed in 1991 reducing active pond area to only 220 hectares. Should these closed farms manage to reopen, the area of ponds in operation could jump dramatically, though the authors do not have information to determine when, or if, this might happen (appendix B).

III. SPECIES

Belizean growers have focused entirely on marine shrimp. The authors are unaware of any freshwater shrimp operations.[2] All growers currently utilize a Pacific white shrimp (*Penaeus vannamei*), the most widely used shrimp species for pond culture in Latin America. *P. vannamei* is popular due to its excellent survival and growth characteristics in ponds and its popularity in export markets. *P. vannamei* is an exotic species to Belize, as it does not naturally occur off of the country. As a result, growers must import postlarvae (pl) from other countries. Early growers experimented with other species, including *P. monodon* and *P. stylirostris* (exotic species) and *P. notialis* (a native species).[3] *P. vannamei*, however, has been the only species cultured since 1990.[4]

IV. COMPANIES

The authors have information on seven farms in Belize (appendix C). Three farms were in operation during 1991:

Aqua-Mar Belize: Aqua-mar opened in 1991. The company, which is located in the south near Independence, currently operates 2.5 - 4 ha intensive ponds.[5]

NOVA Companies: NOVA Companies purchased the **Maya Mariculture** site near Belize City and began operating in 1990.[6] The company currently is the largest Belizean farm operateing 190 **ha** of semi-intensive ponds.[7]

Laguna Madre: Laguna Madre Shrimp Farm (19.2 ha), a U.S.-owned firm which is located in the south near Independence, operates twelve 1.6-ha intensive ponds using Taiwan technology.[8]

Two Belizean farms have been temporarily closed:

Caribbean Shrimp: Caribbean Shrimp, a Canadian-Taiwan joint venture located outside of Belize City, did not stock its 16-ha pond in 1991.[9]

QK Ltd.: QK, located in central Belize near Dangriga, formerly operated a 4-ha semi-intensive farm. The facility is temporarily closed.[10]

Two farms were closed and up for sale:

General Shrimp: General Shrimp opened in 1988, with 110 ha of semi-intensive ponds and a *P. vannamei* hatchery. The company in 1989 reported feed problems and a shortage of capital, which forced it to close.[11] The hatchery and the remaining ponds are inactive and for sale.

Allen Farms: This 54-ha site is closed. The owner would like to sell and is reportedly seeking interested investors.

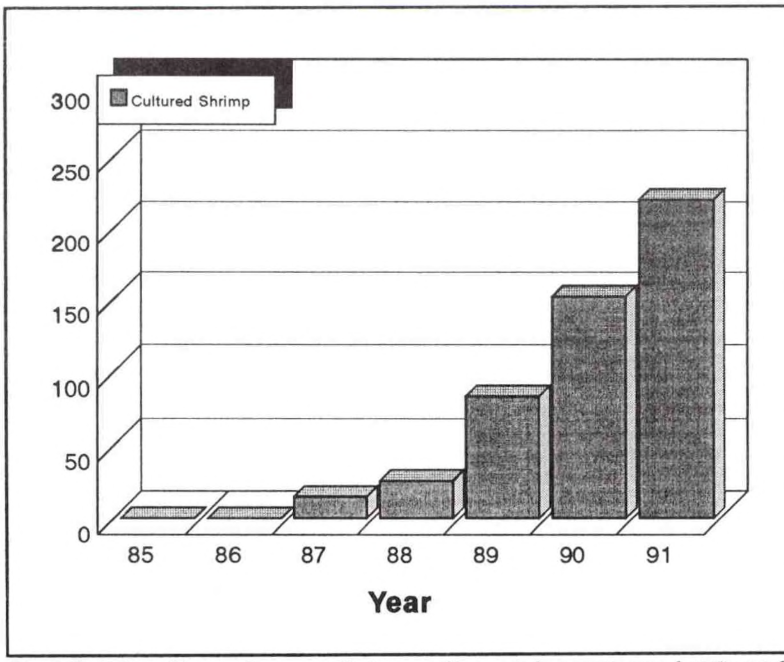

***Figure 1.**--Belize. Growers have steadily increased harvests in recent years, but the total remains less than 300 tons.*

V. HARVESTS

Belizean shrimp growers have reported only small harvests since 1987 (figure 1). Growers reported increases each year, but by 1990 still only harvested 152 tons. Growers may have substantially increased production in 1991. The Government estimates a harvest of over 400 tons. This estimate, however, has not been confirmed by other sources. While the Belizean harvest is limited, it is the only known commercial harvest reported along the Caribbean coast of Central America from Mexicc (Quintana Roo) south to Panama.

VI. PROCESSING

Three companies, NOVA Companies, General Shrimp (inactive) and Laguna Madre, have their own processing plants. Laguna Madre, until 1991, shipped most of its shrimp to a processing plant in Honduras, because Belizean processing plants were unable to consistently process and store the large amounts of shrimp the company produced. Allen Farms (inactive) and Caribbean Shrimp, both located near Belize City, use the processing facilities of the Northern Fishermen Cooperative Society (which primarily processes lobster).[12]

VII. POSTLARVAE SUPPLY

Growers must either produce pl in hatcheries or import it, because *P. vannamei*, the species utilized by Belizean growers, does not occur off of Belize. The country has two hatcheries, both of which must import *P. vannamei* nauplii to produce postlarvae.

Laguna Madre: Laguna Madre constructed a hatchery in 1991. The capacity is 4.8 million pl per month.[13]

NOVA Companies: Nova Companies completed a hatchery in early 1992. The hatchery will have a capacity to produce 4.0 million pl per month.[14]

VIII. GOVERNMENT ROLE

The Belizean Government has played an important role in the development of the country's shrimp culture industry. The Ministry of Economic Development, in an effort to support export oriented enterprises such as shrimp farms, grants, and import duty, income, and corporate tax exemptions for up to 15 years. Many shrimp farms have received these benefits. The Government also plans to provide training and financing to help small operators build ponds and buy equipment.[15] The development of the shrimp culture industry is a Belizean Government priority. At an Export Development Seminar sponsored by Belizean Ministry of Natural Resources and the Chamber of Commerce, one senior Government economist at the Ministry of Economic Development said that "the Government would encourage in every way possible the development of aquaculture and mariculture enterprises."[16]

IX. FOREIGN ASSISTANCE

Many growers report difficulties in obtaining local funding. As a result, almost all of the investment capital for Belizean shrimp farms has come from foreign sources, primarily the United States. Most of the important investors and operators are U.S. citizens. U.S. investors have thus far been willing to invest, but lack of initial success is discouraging additional investors. Future funding will be strongly influenced by the profitability of current Belizean shrimp farms. Two other foreign groups have also provided assistance to Belize's shrimp culture industry. The Government of Taiwan, in 1990, signed an agreement to provide technical assistance to Belize. This agreement provides for help in setting up a 8-ha shrimp farm and hatchery.[17] The World Bank lent $1 million to assist in the development of shrimp farms. These funds were to be used to strengthen the Fisheries Unit's technical capability so it could provide effective extension services. The Fisheries Unit hopes to develop the ability to assist growers in site selection, pond engineering, disease management, processing, and other technical matters.[18]

X. OUTLOOK

Belizean growers and Government officials have promoted the development of shrimp culture as a potential new non-traditional export industry. Early developments indicate that some potential exists for shrimp culture. The initial growers, however, have reported financial difficulties. Potential new investors have been reluctant to finance additional operations. Basic physical conditions appear adequate, but the lack of an indigenous shrimp species has proven a limiting factor. Improvements in hatchery technology and the development of seedstock suppliers in Panama and other countries may make this a less important factor during the 1990s. If growers could fully stock existing ponds, Belize is capable of harvesting about 1,000 t of shrimp annually. Even modest expansion during the 1990s should enable growers to achieve a harvest of 2,000 - 3,000 t by the year 2000.

This report was originally prepared by Randolph Wells, Dennis Weidner, and Tom Revord and published as IFR-92/54 on July 24, 1992.

SOURCES

Belize Fishermen Cooperative Association, *Quarterly Newsletter*, June 1991.

Maugle, Paul D. "Feasibility of Freshwater Prawn Production in Belize," PDM & Associates, prepared for RDA International, January 1990.

Myvett, George. "An Update on the Status of Aquaculture in Belize," Ministry of Agriculture and Fisheries, July 31, 1991.

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Pinto, S.E., Belize Fishermen Cooperative Association. Personal communications, June 27, 1990.

RDA International, "Ecological and Economic Impacts of Shrimp Trawling in Belize," prepared for USAID/Belize and the Belize Ministry of Agriculture, Forestry and Fisheries, April 15, 1991.

__________. "An Assessment of the Present Status, Competitive Position, and Long-Term Potential of the Belizean Shrimp Culture Industry" prepared for USAID/Belize and the Belize Ministry of Economic Development, June 9, 1989.

Snell, John R. President, General Shrimp Ltd. Personal communication, May 30, 1990.

ENDNOTES

SECTION I (Capture Fishery)

1. A detailed review of catch rates, bycatch, trawling grounds, and the ecological impact of shrimp trawling has been prepared by a U.S. consulting group. See RDA International, "Ecological and Economic Impacts of Shrimp Trawling in Belize," prepared for USAID/Belize and the Belize Ministry of Agriculture, Forestry and Fisheries, April 15, 1991.

SECTION III (Species)

2. For details on Belizean freshwater shrimp culture, see Paul D. Maugle, "Feasibility of Freshwater Prawn Production in Belize," PDM & Associates, prepared for RDA International, January 1990.

3. References to *P. duorarum* probably refer to *P. notialis*.

4. George Myvett, "An Update on the Status of Aquaculture in Belize," Ministry of Agriculture and Fisheries, July 31, 1991.

SECTION IV (Companies)

5. Myvett, "An Update on the Status of Aquaculture in Belize," *op. cit.*

6. S.E. Pinto, Belize Fishermen Cooperative Association, personal communications, June 27, 1990.

7. Myvett, "An Update on the Status of Aquaculture in Belize," *op. cit.*

8. Myvett, "An Update on the Status of Aquaculture in Belize," *op. cit.*

9. Myvett, "An Update on the Status of Aquaculture in Belize," *op. cit.*

10. Myvett, "An Update on the Status of Aquaculture in Belize," *op. cit.*

11. General Shrimp reported difficulties in obtaining quality feed in 1988 and 1989, and claimed that low-quality feed was responsible for the poor performance of its growout ponds. John R. Snell, personal communications, May 30, 1990.

SECTION VI (Processing)

12. Myvett, "An Update on the Status of Aquaculture in Belize," *op. cit.*

SECTION VII (Postlarvae Supply)

13. Myvett, "An Update on the Status of Aquaculture in Belize," *op. cit.*

14. Myvett, "An Update on the Status of Aquaculture in Belize," *op. cit.*

SECTION VIII (Government Role)

15. Myvett, "An Update on the Status of Aquaculture in Belize," *op. cit.*

16. *Quarterly Newsletter*, Belize Fishermen Cooperative Association, June 1991.

SECTION IX (Foreign Assistance)

17. Bridgetown CANA Television, Belize City, January 23, 1991 and Myvett, "An Update on the Status of Aquaculture in Belize," *op. cit.*

18. Myvett, "An Update on the Status of Aquaculture in Belize," *op. cit.*

APPENDICES

Appendix A--Belize. Shrimp production, 1980-91.

Year	Production			Share
	Culture	Capture	Total	Cultured
	Metric Tons			Percent
1980	-	58	58	-
1981	-	30	30	-
1982	-	15	15	-
1983	-	10	10	-
1984	-	2	2	-
1985	NA	55	55	NA
1986	NA	250	250	NA
1987	15	259	274	5
1988	26	242	268	10
1989	84	118	202	42
1990	152	148E	300E	51
1991	220E	NA	NA	NA

NA - Not Available
E - Estimate
Sources: George Myvett, Senior Fisheries Officer, Ministry of Agriculture and Fisheries, personal communications, September 13, 1991 (cultured). FAO Yearbook of Fishery Statistics, 1989 (capture).

Appendix B.--Belize. Marine shrimp pond area 1987-91.

Year	Pond area	
	Constructed	Operating
	Hectares	
1987	440	380
1988	501	441
1989	695	695
1990	695	220
1991	933	220E

Source: George Myvett, Senior Fisheries Officer, Ministry of Agriculture and Fisheries, personal communications, September 13, 1991.

Appendix C.--Belize. Marine shrimp farm pond area, 1991.

Farm	Pond Area	
	Constructed	Operating
	Hectares	
Allen Farms	135	-
Aqua-Mar Belize	10	10
Caribbean Shrimp	40	-
General Shrimp	290	-
Laguna Madre	48	20
NOVA Companies	400	190
QK Ltd.	10	-
Total	933	220

Source: George Myvett, Senior Fisheries Officer, Ministry of Agriculture and Fisheries, personal communications, September 13, 1991.

3.2

COSTA RICA

The Costa Rican shrimp culture industry has experienced a variety of difficulties. The industry lags behind the industries which have developed in most other Central American countries. Only a few commercial growout operations are currently active. Suitable sites exist for pond construction, although estimates of the potential area vary from 4,000-9,000 hectares. In addition, some observers believe that existing salt ponds could be converted for shrimp culture. Growers have made some progress in 1990 and 1991 and many believe that the country has the potential to develop a small shrimp culture industry. The difficulties do not appear to be due to any physical constraint, but rather to the limited technical capability and poor planning of early growers and the country's overall economic difficulties. Potential growers report continued problems obtaining credit. Harvests totaled about 400 metric tons in 1990 and will exceed 600 tons in 1991. The potential exists for considerable expansion during the 1990s. Based on the experience to date, however, the industry is likely to expand slowly. Harvests of about 5,000 tons by 2000 appear to be a reasonable projection.

CONTENTS

I. AQUACULTURE INDUSTRY

Costa Rica has a small aquaculture industry. The Government created a Departamento de Acuacultura (DA) in 1974 which is administratively part of Dirección General de Recursos Pesqueros y Acuacultura of the Ministerio de Agricultura y Ganaderia. The DA has primarily focused on freshwater fish culture. The country's actual cultured harvests are very limited, totaling only about 400 metric tons (t) in 1989, mostly marine shrimp, tilapia, and trout.[1]

II. CAPTURE FISHERY

The Costa Rican shrimp fishery is conducted almost entirely along the country's Pacific coast. Costa Rica has the longest Pacific coast (580 kilometers) in Central America, but a relatively small shrimp catch. Fishing is complicated by the

Map 1.--Costa Rica.

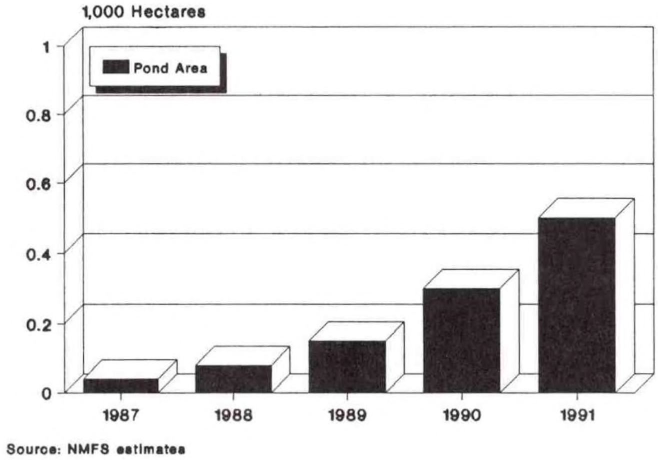

Figure 1.– Costa Rica. Growers have steadily expanded pond area since 1987, but the total area is still very small.

The Costa Rican shrimp catch varied from 3,500 to 4,600 t in the early 1980s. Fishermen reported a substantial increase in the mid-1980s and catches from 1985 to 1989 have been stable at 8,700 to 8,900 tons.[2] Details on this significant expansion are not available. It may be acually due to changes in reporting systems. At least some of it may be incorrectly reported Nicaraguan-origin shrimp. Much of the Costa Rican catch is reportedly small, low-value shrimp, although precise catch data by species is unavailable. Despite the reported catch increase, fishermen and processing companies have reported financial problems.[3] Various observers relate problems in the fishery to the artisanal harvest of juveniles, climatic conditions, and the extensive agricultural use of insecticides.

characteristics of the coast which is broken by a series of peninsulas and gulfs, unlike the largely straight coastlines of other Central American countries. The only fishing port of any consequence is Puntarenas in the north, although Golfito in the south has some possibility. Shrimp occur along most of the coast, but fishing grounds are interrupted by stretches of rocky bottom. Instead of the desirable sandy bottom, much of the country's narrow continental shelf is rocky. The narrow shelf, despite the relatively long coast, results in a fairly small shelf area, limiting the shrimp resource. The major shrimp ground is located in the Gulf of Nicoya where fishing is permitted during an 8-month season from August to April. The interior areas of the Gulf are reserved as a nursery area for juvenile shrimp and trawling there is prohibited year-round. Other grounds include the Bahía de Coronado and Golfo Dulce to the south. Elsewhere the precipitous coastline limits both nursery grounds and trawling areas.

Costa Rica has both an artisanal and commercial shrimp fishery. Artisanal fishermen operate about 1,000 small boats (under 8 meters) in the Gulf of Nicoya. The commercial trawl fleet consisted of about 90 vessels in 1990. Most of the vessels operate in shallow coastal waters.

III. SPECIES

Costa Rican fishermen report commercial catches of a variety of species. The most important *Penaeid* species are reportedly *Penaeus occidentalis, P. californiensis, P. stylirostris*, and *P. brevirostris*. Other species include *Xiphopenaeus rivetti, Solenocera sp., Trachypenaeus sp.*, and *Heterocarpus sp.*[4] Other sources also list *P. vannamei* as a *Penaeid* species occurring off Costa Rica, but it reportedly does not constitute a major share of the commercial catch. Data on the relative importance of these species is unavailable.

IV. GROWING CONDITIONS

Costa Rica has made little progress in developing a shrimp culture industry, but most observers are convinced that the country has the appropriate growing conditions to do so.[5] Conditions in Costa Rica appear to be at least as favorable as in neighboring Panama, which has several successful farms. Growing conditions are favorable because of the tropical climate. Mean maximum temperatures can reach 30°C. Sea surface water temperatures generally range from 26°-29°C. There are two seasons along the Pacific coast, the rainy season (May-November) and the dry season (December-April). The Caribbean coastal plain receives heavy rainfall throughout the year. Specific data on hydrological and soil conditions are not available. Some observers report areas with ideal conditions. Others report problems with pollution and overly acidic soils, especially in the mangrove areas.[6]

V. AREA

Observers vary on the area suitable for pond construction. The U.S. Agency for International Development (AID) estimates that about 4,000 hectares (ha) in Costa Rica could be utilized for shrimp culture.[7] Another source citing a Private Agribusiness and Agroindustrial Council (CAAP) study suggests that the area may exceed 9,000 hectares.[8] Some attempts have been made to use satellite data to identify possible farm sites.[9] While the exact potential is unknown, most observers believe that a substantial number of Pacific-coast sites could be developed. In addition, it may be possible to convert many existing, but unprofitable salt evaporation ponds into shrimp farms. (See "Salt Ponds".)

Despite the considerable potential, only a small number of farms have been built. Estimates made in 1990 suggest that pond area totaled about 300 hectares.[10] A more recent estimate suggests that the area may have reached 500 ha in 1991 (appendix B and figure 1).[11]

VI. CREDIT

The industry's development has been slowed by a lack of available credit, both foreign and domestic. Some foreign investors have reported difficulties with Costa Rican investment laws. The major cause of the credit shortage, however, is Costa Rica's enormous foreign debt, one of the largest per capita debts in Latin America. The massive debt overhang has driven interest rates up and severely limited available credit. In addition, Costa Rican banks have been reluctant to lend to potential shrimp growers following the failure of an early project, **Maricultura**, in 1982.[12] Maricultura, which was financed by the Costa Rican Development Corporation (CODESA), the World Bank's International Finance Corporation, private interests, and local banks, began operations in 1975 and eventually built 130 ha of marine shrimp ponds and a hatchery. The company attempted to grow both *Penaeus vannamei* and *P. stylirostris*. From the beginning, Maricultura was plagued by excessive construction costs, high operating expenses, and water quality problems. The project reported continued deficits and finally closed in 1982.

The Maricultura failure reportedly caused potential investors to reassess possible involvement in shrimp culture projects. Many private banks restricted loans, demanding that shrimp farmers deposit substantial collateral to back their operations. Addressing this problem, the CAAP contracted an aquaculture study through U.S. AID in 1987. The study concluded that there was considerable potential for aquaculture development in Costa Rica.[13] Commercial banks reportedly showed renewed interest in shrimp culture investment after reviewing the CAAP study, but there are still only a small number of farm projects.

VII. POSTLARVAL SEEDSTOCK

Only limited information exists on the availability of shrimp postlarvae (pl) off Costa Rica. One researcher at the Centro de Investigacion en Ciencias del Mar y Limnologia of the Universidad de Costa Rica is studying the ecology of shrimp postlarvae. The study focuses on the Estero de Cocoroca in the Gulf of Nicoya and deals with *Penaeus californiensis, P. occidentalis, P. stylirostris*, and *P. vannamei*.[14] The relative unimportance of P. vannamei in the commercial shrimp catch suggests that P. vannamei pl may be relatively scarce. One observer maintains that the availability of pl is the principal problem currently facing the industry.[15]

Some progress is reportedly being made with the production of hatchery postlarvae. **Cosechas Marinas** has for several years operated a hatchery with the capacity to produce 70 million pl per year, and has now enlarged it. The company plans to produce 170-200 million pl in 1991 without the use of antibiotics. The pl are for use in the company's growout ponds and export to Honduras. Company officials say they also eventually hope to export to Mexico.[16] **Fincas Marinas Golfiteñas** has also built a hatchery, which focuses primarily on P. stylirostris. No other details are available.

VIII. METHODS

Costa Rican growers are primarily using extensive methods. The DA, through its new marine shrimp culture development program, is suggesting that new growers stock at densities of 20,000-30,000 pl per ha and apply fertilizer, but not use supplemental feeding. The DA recommends that more experienced growers should increase densities to 40,000-50,000 pl per ha and begin supplemental feeding. Yields through 1989 ranged from 0.3-1.0 t per hectare. Some growers reported much improved results in 1990 and 1991. Both Cocechas Marinas and Criadero de Camarones de Chomes, the country's two most important farms, have shifted to semi-intensive methods and are reporting sharply higher yields. (See "Farms.")

IX. FARMS

Costa Rican growers are attempting to culture both marine and freshwater shrimp.

A. Marine

Two semi-intensive commercial shrimp culture projects and two hatcheries are currently active along the Pacific coast, primarily using *P. vannamei*, but also some *P. stylirostris*. Farms are concentrated in the Gulf of Nicoya area (appendix A and figure 1). Most of the other growers are using extensive methods.

Cosechas Marinas S.A. (CM) is Costa Rica's major commercial shrimp farm. It is affiliated with one of Costa Rica's principal meat packing companies. CM opened in 1987 with 16 ponds (80 ha) and a hatchery on a 350-ha site near Quepos[17] and a second site further south. The company's first hatchery initially had the capacity to produce 70 million pl per year.[18] A recent report suggests that total production capacity has increased to 170 million pl annually.[19] CM sells pl to other Costa Rican growers and exports pl to Honduras and the United States.[20] The company has expanded pond area and operated 150 ha in 1991.[21] It plans to harvest 500 t of shrimp in 1991.[22] CM reports impressive yields of 2.0-3.0 t per hectare.[23]

Criadero de Camarones de Chomes (CCC) (the former **Maricultura** site) has 80 ha of ponds. The site was bought in 1986 by a Canadian company, ASCI-BIOREX. The farm was redesigned and the resulting construction project completed in mid-1988. The farm manager initially encountered fairly acidic soils, but has reportedly been able to maintain acceptable pH ranges. The company is reporting excellent results, 2 t of shrimp per crop in a 120-day cycle, or 4-6 t per year. The harvests are mostly 31-35 count (20 gr) shrimp.[24]

Fincas Marinas Golfiteñas built 22 ponds of 0.5 ha each on a 220-ha site near Golfito. The ponds rely on tidal flows for water exchange, and a small hatchery on the Golfo Dulce provides *P. stylirostris* postlarvae.

Langostinos del Pacifico is also reportedly active, but no information is available.[25]

B. Freshwater

Costa Ricans are also trying to culture freshwater shrimp. Results have been largely unsatisfactory, but some remain convinced that freshwater shrimp culture could prove profitable.

Photo 1.--*Costa Rica. Pond bottom maintenance at the Cosechas Marinas farm using a Mud-Wrestler tiller.* © *C. Lara*

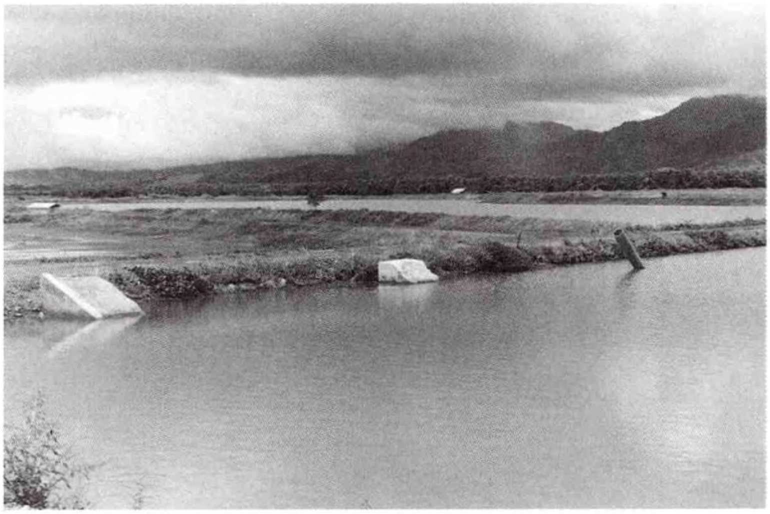

Photo 2.--Costa Rica. View of the Langostinos del Pacifico growout ponds near Quepos. *@ Jorge Pang*

Acuacultura, the first freshwater project, was built in Guanacaste Province and included 40 ha of growout ponds and a small hatchery. The project was also financed by CODESA, and while it reported some successful harvests, production costs were prohibitive, forcing it to close in 1985.[26] One of the company's principal problems was its location, which required the drilling of deep wells and extensive pumping, sharply escalating production costs. Other problems included water quality at the hatchery and sharply higher costs for imported equipment, materials, and other items after the value of the Costa Rican colon dropped precipitously in 1982.[27]

One **unidentified group** is considering using the old Langosta del Coco farm which has 50 ha of ponds.

CORBANA is conducting polyculture runs of fish and freshwater shrimp in its semi-intensive ponds at "28 Millas" and "La Rita".[28]

Other groups have expressed an interest in experimenting with shrimp culture, including several farmers who raise a variety of agricultural crops.

X. HARVESTS

Costa Rican shrimp harvests are still minimal. Farmers are increasing harvests, but the 1989 harvest was still only about 135 t (appendix B). Observers estimate that the 1990 harvest, however, may have been as high as 400 tons (figure 3).[29] The only hard data available is from Alimentos Congelados Oro, which processed about 335 t of cultured shrimp over a 12-month period.[30] Some observers projected a 1991 harvest exceeding 600 tons. The excellent results being reported by CM and CCC, however, suggest that the actual 1991 harvest may be even higher.

Future prospects are difficult to assess given the wide range of estimates on potential sites and the difficulties the industry has experienced in the past. Continued credit shortages suggest that pond construction will proceed slowly. Based on the encouraging results reported in 1990 and 1991, however, Costa Rican growers may be able to steadily expand pond area and harvests during the 1990s. A harvest of about 5,000 t by 2000 appears to be possible if growers are able to obtain credit and the progress reported in 1990-91 is sustained. The county's potential, however, is much larger. Using a relatively conservative pond area estimate of 5,000 ha and average annual yields of about 2 t per ha, growers should eventually be able to harvest at least 10,000 t of shrimp along the Pacific coast alone. Continued improvements in yields and development of Caribbean coast sites, could enable growers to eventually achieve production levels approaching 20,000 tons.

XI. SALT PONDS

Costa Rica has 2,500 ha of salt ponds, the majority located along the northern Pacific/Gulf of Nicoya coast. Many salt producers, motivated by high production costs and lower demand, have been seeking alternative uses for these ponds. About 50 individuals operating about 500 ha of ponds have expressed an interest in conversion.[31] Several salt producers have previously made attempts to culture shrimp during the inactive rainy season (May through November). About 15 growers have reported experiments with 200 ha of inactive salt evaporation ponds.[32] Shrimp harvests from these operations have, however, been very small to date.[33] Juvenile shrimp and fish enter ponds at this time with the tides and are unable to escape. Operators made no attempt to control species, predators, or water levels.[34] Some operations, however, such as the **Cooperativa Nacional de Productores de Sal** have expressed an interest in purchasing shrimp nauplii.[35]

Various national and international institutions are independently promoting shrimp culture as an alternative use. These groups include: the National Council of Cooperatives (CONACOOP), the National Institute of Cooperative Promotion (INFOCOOP), the Interamerican Institute of Farm Sciences (IICA) and other domestic and foreign groups. The economics of the conversion are unproven, but some observers are optimistic.[36] Conversion of salt evaporation ponds to shrimp culture sites would cost about $2,900-$8,000 per hectare. U.S. AID estimates an average cost of $3,600, substantially less than new pond construction of about $5,000 per hectare. CONACOOP, in 1987, started a pilot program to culture shrimp in salt evaporation ponds through a loan from the National Bank of Costa Rica. Project managers found that many evaporation ponds did not have proper access to fresh water and irrigation canals had to be installed. In addition, salinity and pH levels in many ponds were not suitable for shrimp culture, requiring substantial modifications. Despite these limitations, many believe that converted salt ponds could eventually be used for profitable farms.[37]

One promising new venture is **Artemarino**, SA, an intensive integrated system which will produce shrimp, *Artemia*, and salt. The company has 12 ha of ponds, including shrimp growout ponds (7 ha), *Artemia* ponds (3 ha), and a salt crystallizer (1 ha). The project maintains about 20 percent daily water exchange with two 40 cubic meters (m^3) per minute pumps which circulate water from Estero Copal. The water is pumped into the growout ponds then onto the *Artemia* ponds, and finally to the salt crystallizer or outflow drain, depending on the season.[38]

XII. GOVERNMENT ROLE

The Costa Rican Government has played only a minor role in the shrimp culture industry's development. The failure of Maricultura has caused Government agencies to reject future commitments to the industry. In addition, the fiscal crisis beginning in 1982 has sharply limited the Government's ability to finance development projects.

Consejo Nacional de Cooperativas: CONACOOP, the Banco Nacional, and the Inter-American Development Bank promoted a program to culture shrimp in salt evaporation ponds.[39] Financing was obtained from the Banco Nacional at 17 percent interest and a 8-year grace period. The results obtained were disappointing.[40]

Departamento de Acuacultura: The DA in 1989 launched a marine shrimp culture development project which includes both promotion and technical assistance. The project is primarily directed at assisting small-scale growers in the Gulf of Nicoya area with at least 5 ha of ponds.[41]

XIII. RESEARCH/TRAINING

Several groups are reportedly researching shrimp culture.

Marine species: The Escuela de Ciencias Biolgicas (ECB) at the **Universidad Nacional** (UA) in Heredia has done some work on marine shrimp aquaculture. Several companies are conducting research programs, especially **Criadero de Camarones de Chomes, Cosechas Marinas**, and **Fincas Marinas del Golfito**.

Freshwater species: The DA's **Centros de Investigacion y Producción** (CIPs) have done some limited work on freshwater shrimp, but have primarily focused their efforts on finfish. The DA has established six CIPs. Five work on warm-water species and one works on colder-water species, mostly trout. The **Atlantic Coast Port Authority** (JAPDEVA) has an experimental farm at Limon to promote the industry. The **Taiwan Aid Mission**, based at nearby Finca Castro, is assisting JAPDEVA. The **Instituto Tecnologico de Costa Rica** (ITCR) has an experimental freshwater shrimp farm along the Río San Carlos in the north. The ITCR project receives assistance from the Japanese Government.[42] A private association (**ASBANA**) has been experimenting with freshwater shrimp since 1976 and operates experimental ponds and a hatchery. The **Escuela de Agricultura de la Region Tropical Humido** (EARTH) is building a research station at Guapiles for freshwater shrimp.[43] Private companies have also done some work, especially **CORBANA**.

Artemia: Limited work has also been conducted with *Artemia*. Roman Odio, in 1983, inoculated a mixture of San Francisco Bay and Great Salt Lakes *Artemia* in the Salinera Soley (Bay of Salinas, Guanacaste Province) salt ponds. The Artemia are reportedly still flourishing.[44]

Few Costa Rican academic institutions offer aquaculture training programs. Government officials believe that the shortage of trained personnel is a major impediment to the industry's development.[45] Some general aquaculture programs are available. The **Colegio Universitario de Puntarenas** and **UA** offer courses in aquaculture, fisheries biology, and fisheries technology, but no information is available on the programs. Other institutions have expressed an interest in aquaculture. The **Universdad de San Jose** hopes to initiate an aquaculture degree program in 1992.[46] Costa Rica currently, however, has no academic programs specifically devoted to shrimp culture. The Government's new marine shrimp culture program initiated in 1989 provides some extension services to small-scale growers.

XIV. OVERVIEW

The Costa Rican shrimp culture industry lags behind developments in most other Central American countries. Only a few commercial growout operations are currently active. Growers made some progress, however, in 1990 and at least two farms are reporting excellent 1991 results. Small harvests are being acheived, but many growers continue to report a variety of problems. The most serious problem appears to be credit. Other problems include pollution and acidic soils. Despite these difficulties, most observers are convinced that excellent sites exist for shrimp ponds and the country has the potential for a small shrimp culture industry. If potential farmers can obtain credit and problems with converted evaporation ponds can be solved, the industry could begin to report the kind of progress achieved in Honduras, Panama, and other neighboring countries. Growers should be able to achieve a 5,000 t harvest by 2000 if the progress achieved in 1990 and 1991 is sustained during the 1990s.

This report was originally prepared by Dennis Weidner and Tom Revord and published as IFR-91/49 on July 19, 1991.

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ENDNOTES

SECTION I (Aquaculture Industry)

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SECTION II (Capture Fishery)

2. Costa Rican Government submission to FAO. FISHDAB. Data collected by the U.S. Embassy suggests a substantially smaller catch. The Embassy reported a 1988 shrimp catch of only about 3,900 tons. (The Embassy reported 2,300 t, but this was probably tail weight.) U.S. Embassy, San Jose, March 6, 1990.

3. J. Mizuishi and R. Rackowe, "Export Development at Enterprise Level of Shrimp and Shrimp Products from Central American Countries: Costa Rica," International Trade Center (ITC/DTC/90/1143), January 22, 1990.

SECTION III (Species)

4. U.S. Embassy, San Jose, March 6, 1990.

SECTION IV (Growing Conditions)

5. Juan Luis Córdoba Mora, Ministerio Agricultura y Ganaderia, "El Cultivo de Camarones en Costa Rica," *Simposio Centroamericano Sobre Camaron Cultivado*, Honduras, April 24-26, 1991.

6. Córdoba, *op. cit.* A good review of available information on pollution has been prepared by FAO. See Jairo J. Escobar Ramírez and Uwe Barg, "La contaminación de las aguas continentales de Bolivia, Colombia, Costa Rica, Ecuador, Panamá, Perú y Venezuela," *COPESCAL Documento Tecnico*, FAO, 1990, pp. 7-9.

SECTION V (Area)

7. Peter Bartlett, "Tecnicas y Avances del Cultivo de Camarón en Costa Rica" in *El Cultivo del Camarón, Langostino y Cangrejo en el Mundo: Bases y Tecnologia*, (McGraw-Hill: Mexico City, 1989).

8. The CAAP study was conducted in 1988 with AID financing. The discrepancy with the other AID estimate is unexplained. Córdoba, *op. cit.*

9. J.M. Kapetsky, L. McGregor, and N.E. Herbert, "A Geographical Information system and Satellite Remote Sensing Plan for Aquaculture Development: A FAO-UNEP/GRID Cooperative Study in Costa Rica," *FAO Fisheries Technical Paper*, No. 287, 1987.

10. J. Mizuishi and R. Rackowe, *Export Development at Enterprise Level of Shrimp and Shrimp Products from Central America*, (UNCTAD/GATT, 1990) and *World Shrimp Farming*, January 1991.

11. Eduardo Velarde Silva, General Manager, Criadero de Camarones de Chomes, personal communications, May 31, 1991.

SECTION VI (Credit)

12. Details on the Maricultura project are available in Enrique Ramirez Guier and Odin Thaanum, "Costa Rican Aquaculture," *Aquatica*, 1985.

13. Bartlett, "Tecnicas," *op. cit.*

SECTION VII (Postlarval Seedstock)

14. Researcher Patricia Jiménez Morales would also like to do some work on larviculture. *Larviculture and Artemia Newsletter*, March 1990, No. 15, p.27.

15. He maintains that the problem is both quality and the availability of pl when needed. Córdoba, *op. cit.*

16. Carlos Lara, Cosechas Marinas, item 16.7.25, *World Shrimp Farming*, July 1991, p.19. and Mario Brenes C., Manager, Cosechas Marinas, personal communications, July 27, 1991.

SECTION IX (Farms)

17. William Mora, "Camarones por dólares," *La Nacion*, March 11, 1987.

18. Córdoba, *op. cit.*

19. Brenes, *op. cit.* and Lara, *op. cit.*

20. Peter Bartlett, CAMARONEX, personal communications, January 21, 1991.

21. Brenes, *op.cit.*

22. Brenes *op. cit.*

23. Córdoba, *op. cit.*

24. Velarde, *op. cit.* Such yields would appear quite high and the authors have no independent verification of them.

25. Bartlett, personal communications, January 21, 1991, *op. cit.*

26. For details see Ramirez and Thaanum, *op. cit.* and Spencer Malecha, "Assessment of Acuacultura S.A. and Proposed Training and Research Center," Prawn Tech, Hawaii, 1982.

27. Higher costs for *Artemia* were particularly burdensome.

28. Earthquake damage caused some losses at the "28 Millas" farm. Jorge Gunther, National Project Coordinator, Programma UNA-LUW Acuacultura, Escuela de Ciencias Biologicas, personal communications, April 30, 1991.

SECTION X (Harvest)

29. Bartlett, CAMARONEX, personal communications, January 21, 1991 *op. cit.*

30. The company data covers October 1, 1989-September 30, 1990 and roughly confirms the overall 1990 estimate of 400 tons. Peter Bartlett, personal communications, April 30, 1991.

SECTION XI (Salt Ponds)

31. Most are located in the Gulf of Nicoya area. Córdoba, *op. cit.*

32. A typical salt evaporation operation ("salina") in Costa Rica consists of several ponds varying from 0.5-1.5 m deep with the highest salinities close to the coast. Operators begin to prepare the ponds in November with salt harvests occurring throughout the dry season until late April or early May when the rainy season begins. Most operators abandon their ponds during the rainy season. Peter C. Phillips, "Aquaculture as an Alternative Occupation on the Pacific Coast of Costa Rica," *ICLARM Newsletter*, Vol. 8, No.2, April 1985, pp. 14-15.

33. Bartlett, personal communications, January 21, 1991, *op. cit.*

34. Bartlett, "Tecnicas," *op. cit.*

35. U.S. Embassy, San Jose, November 24, 1989.

36. Peter Bartlett and E. Zamora, "The Economics of Modifying Salt Evaporation Ponds for Shrimp Farming in Costa Rica," *Artemia Newsletter*, November 1987.

37. Bartlett, "Tecnicas," *op. cit.*

38. Ramon Odio, "New Artemia Company in Costa Rica, *"Larviculture and Artemia Newsletter,"* March 1991, No. 19, p.39-40.

SECTION XII (Government Role)

39. For more details on salt pond conversion, see "Salt Ponds."

40.Córdoba, *op. cit.*

41. Córdoba, *op. cit.*

SECTION XIII (Research/Training)

42. U.S. Embassy, San Jose, June 8, 1987.

43. Gunther, *op. cit.*

44. Odio also reports that the quality and quantity of salt production has increased. Odio, op. cit., p.39.

45. Córdoba, *op. cit.*

46. Bartlett, personal communications, *op. cit.*, April 30, 1991.

APPENDICES

Appendix A.--Costa Rica. Shrimp farms

Acuacultura
Address unavailable

Artemarino
Address unavailable

Cooperativa Nacional de Productores de Sal
Address unavailable

CORBANA
Address unavailable

Cosechas Marinas
PO Box 6072
San Jose 1000
COSTA RICA
Telephone: 506-394-449
FAX: 506-390-402

Criadero de Camarones de Chomes
(former **Maricultura**)
Farm: Apdo. Postal 794-2050
San Pedro
Office: Apt. 5173
San Jose
COSTA RICA
Telephone: 506-610-944
FAX: 506-552-510

Fincas Marinas Golfiteñas
Apdo. Postal 791
Punta Zancudo, Golfita
COSTA RICA
Telephone: 53-45-30
FAX: 53-97-13

Langostinos del Pacifico
Apt. 108
Quepos 6350
COSTA RICA
Telephone: 506-770-356
FAX: 506-770-044

Appendix B. -- Costa Rica. Shrimp pond area and harvest, 1985-91.

Year	Pond area	Harvest
	Hectares	Metric tons*
1985	NA	5
1986	NA	5
1987	40	10
1988	80	50
1989	150	136
1990	300	400E
1991	500P	600**

* liveweight
** Prelimenary reports from individual farms suggest that 1991 harvests could be as high as 700 tons.
E - Estimate
NA - Not available
P - Projection
Sources: NMFS estimates (1985-88 harvest data); INFOFISH International, April 1990 (1989 data); Peter Bartlett, CAMARONEX, personal communications, January 21, 1991 (1990 harvest data) and various other sources (pond area data).

3.3

EL SALVADOR

Only a few Salvadoran growers are currently conducting commercial shrimp culture operations. The protracted civil war discouraged investment in pond construction during the 1980s. Government officials, however, believe the industry to be a promising medium-term fishery investment opportunity and both cooperative and private groups, encouraged by the on-going peace process, are assessing the economic viability. Two farms have recently been renovated and a third newly built farm is almost completed. The country's limited area and the land reform law restrict growers to relatively small farms. As a result, most Salvadoran farms will probably use semi-intensive or intensive systems. The Salvadoran Government offers very attractive financial assistance and investment terms and a private foundation offers technical assistance to both domestic and foreign investors. Available information suggests that the country has the potential to develop a small shrimp culture industry. Climatic conditions and water quality are reportedly excellent and wild postlarval seedstock is readily available in local estuaries. A modern new hatchery is scheduled to open in late 1992. Salvadoran growers have the advantage that they can draw on the increasing technical capability and service industries developing in Guatemala and Honduras to support the rapidly developing shrimp culture industries in those neighboring countries. Salvadoran growers have developed only a fraction of the potential area suitable for culture. Harvests are currently very small--only about 50 metric tons in 1991, but a substantial increase is projected for 1992. Growers confront significant problems, both the obstacles associated with launching a new industry and the difficult economic conditions in the country. Few Salvadorans have extensive experience with aquaculture, especially shrimp culture, but an increasing number of Salvadoran technicians have pursued training courses and academic degrees . Current trends suggest that the industry will expand during the 1990s and because of the extremely small current harvests, the industry could report a very rapid growth rate. Actual increases, however, will be restricted by the war-damaged economy. A harvest of 3,000-4,000 tons by 2000 seems plausible. Some observers believe, however, that the industry will develop even more rapidly.

CONTENTS

I. CAPTURE FISHERY

El Salvador's shrimp industry is dominated by a 90-vessel trawler fleet which operates out of Acajutla, La Unión, and Puerto El Triunfo.[1] The country's shrimp fishing grounds are some of the most intensively fished in the region. Shrimp are caught all along the 330 kilometer (km) coast.[2] El Salvador's shrimp catch averaged 3,300 metric tons (t) between 1986 and 1989 (appendix B2 and figure 1).[3] Catch data for 1990 is not available, although it is estimated to have fallen to only about 2,400 tons. Commercial shrimp fishermen have experienced problems in recent years. The reason for the decline is not well understood. Shrimp catches are affected by a variety of climatic factors. The intense fishing effort may also be affecting stocks. In addition, competition from poachers and artisanal fishermen taking shrimp are also affecting both sales and shrimp stocks.[4] Although the artisanal fishery primarily targets finfish, there is a significant incidental shrimp bycatch. As a result of the declining catch, some observers report that shrimp companies have encountered difficulties in obtaining credit, putting many companies on the brink of bankruptcy.

El Salvador has a large artisanal fishing sector. The country has an artisanal fleet of 3,000 boats and over 19,000 part-time subsistence fishermen.[5] Some of the artisanal fishermen have begun turning to collecting postlarval seedstock. Only a few farms are active in El Salvador, but the artisanal fishermen in the Golfo de Fonseca area have been selling to nearby Honduran growers who have developed the largest shrimp culture industry in Central America.[6]

II. SPECIES

Salvadoran growers primarily culture marine species, though a few small growers also work with freshwater species.

A. Marine

Salvadoran growers culture two indigenous species, *Penaeus vannamei* and *P. stylirostris*.[7]

P. vannamei: Most Salvadoran growers culture *P. vannamei*, a species of white shrimp which occurs along the Pacific coast of Latin America from Mexico (Gulf of California) south to northern Peru. Of all the indigenous Latin American species, *P. vannamei* seems to be the best adapted to estuarine conditions. Juveniles tolerate the sharp swings of salinity,

Map 1.--El Salvador.

temperature, pH, and dissolved oxygen levels which often occur in estuaries (and in ponds) giving it the reputation of a "tough" species. No other indigenous shrimp survives as well in ponds. *P. vannamei* has served as the basic species used by the highly successful Ecuadorean shrimp culture industry, and growers there report that it performs well in both extensive and primitive semi-intensive systems. They also report that it performs well even with inexpensive, relatively low-protein (20 percent) feeds.[8]

P. stylirostris: Salvadoran growers also culture *P. stylirostris*, another species of white shrimp which is found from Punta Abreojos in Baja California south to Tumbes in Peru. Panama and Honduras are the only Latin American countries which culture significant amounts of *P. stylirostris*.[9] Growers achieve lower yields with *P. stylirostris* but are reportedly able to harvest larger, more valuable shrimp than with *P. vannamei*. *P. stylirostris* is also more tolerant of cold water temperatures and appears to be more disease resistant than *P. vannamei*. *P. stylirostris*, however, requires higher quality, more expensive feed than normally used for *P. vannamei*.

Other species: Salvadoran research groups have done only limited work on other marine species.[10] Individual farms have also done some work,[11] but little of this work has been published.

B. Freshwater

Freshwater farmers use *Macrobrachium rosenbergii*, the most common freshwater species employed for culture in Latin America. Some experimental work was initiated as early as 1975 with freshwater indigenous species (*M. tenellum* and *M. americanus*).[12] Commercial trials with these species, however, have proved generally unsuccessful.[13]

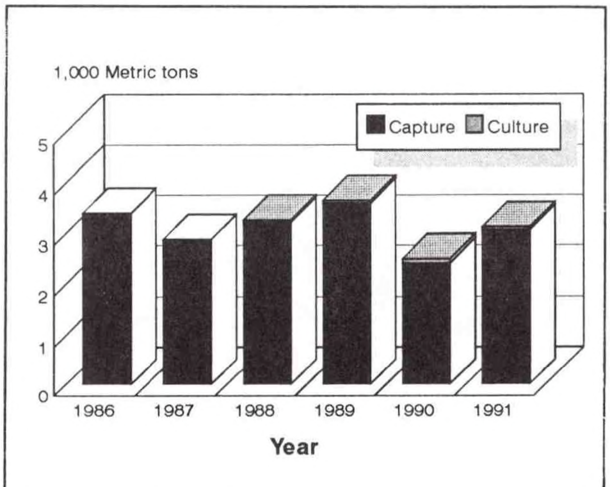

Figure 1.--*El Salvador. Most Salvadoran shrimp is captured by the trawler fleet.*

III. AQUACULTURE

Aquaculture is a new industry in El Salvador. Few Salvadorans have experience or technical training in aquaculture and very few commercial operations are currently active.

1950-60s: The first aquaculture activity reported in the country began in 1957 when the Salvadoran Government constructed the Estación Nacional de Piscicultura de Santa Cruz Porrillo. FAO provided technical assistance and research focused on the possible introduction of exotic species.[14] A Government research group prepared a survey of species with potential for aquaculture and developed pond designs suitable for Salvadoran conditions.

1970s: The Government and a few private investors attempted to develop the industry during the 1970s as the Government expanded its aquaculture research program. The Government also obtained assistance from various foreign donor and consulting groups, including the U.S Peace Corps, the U.S. Agency for International Development (AID), Auburn University, the Inter-American Development Bank, and the Canadian International Development Agency (CIDA). The Government initiated a major effort in 1973 to build 100 small communal ponds in rural areas throughout the country.[15] Some growers initiated small operations. One estimate suggests that about 500 ha of ponds had been constructed by 1975.[16] Much of the activity focused on tilapia, although work was also carried out on carp, freshwater and marine shrimp, oysters, and a variety of indigenous finfish. The Government constructed four new aquaculture research stations at Puerto El Triunfo, Izalco, Atiocoyo, and Guajoyo. The Government negotiated a IDB fisheries and aquaculture loan in 1977 and $1.5 million was earmarked for pond construction. About 30 ha of ponds were built, many are still operating and producing tilapia and freshwater shrimp.[17]

1980s: Some work on aquaculture continued during the 1980s, although many operations were impaired by the hostilities and lack of security in rural areas.[18] The Government experimented with an integrated polyculture system using tilapia and carp culture in connection with ducks and pigs. Other work dealt with cage culture, focusing on tilapia. The work was carried out in some of the country's lakes (Coatopeque, Guija, Ilopango, and Metapan).[19] The Government produced carp fingerlings and began to give increasing attention to research on shrimp culture. Other work was done on mussels and ornamental tropical fish. Some limited efforts were made to initiate aquaculture projects in an effort to provide food and employment for displaced persons fleeing the civil war.[20] Government officials are studying the possibility of other aquaculture projects for snails, turtles, clams, redfish, alligators, catfish, and frogs.

Overall progress with commercial aquaculture has been limited. While the country has a significant potential for aquaculture, given its extensive freshwater resources, actual harvests are extremely small. FAO reported cultured finfish harvests of less than 500 t in 1989.[21] The limited development of the overall aquaculture industry has proven to be an impediment to the development of shrimp culture in El Salvador. Few Salvadorans have even basic academic background in aquaculture or experience with either finfish or shellfish farms. In addition, the necessary support industry supplying services, equipment, and supplies is undeveloped. Salvadoran growers, however, can benefit from the technical capability, experience, and service industries rapidly developing in Guatemala and Honduras to support the dynamic shrimp culture industries in those neighboring countries. This may prove to be a significant advantage to Salvadoran growers.

IV. INFRASTRUCTURE

Salvadoran growers have access to one of the best developed infrastructures in Central America, despite the damage resulting from the protracted fighting during the civil war.[22] All weather roads lead to all three areas identified as most suitable for marine shrimp culture. (See Section V. Area.) Many site, however, will require the construction of local access roads to connect farm sites to the main roads. One major advantage in El Salvador is the availability of electrical power. Electricity is less expensive than in other Central American countries and growers in most areas should be able to obtain electrical connections at reasonable cost.[23] The small size of the country provides growers ready access to both the San Salvador airport (Comalapa International Airport) for both fresh and frozen shipments and ports for shipping frozen product. Growers also have access to ports in Guatemala and Honduras. The regular flights and freight shipments are also advantageous to Salvadoran growers.[24] This ready access to the U.S. market gives Salvadoran and other Central American countries an advantage over South American competitors. This price advantage is especially pronounced for fresh product. The Salvadoran Foundation for Economic and Social Development (FUSADES) reports that they have obtained a concession from an airline to ship fresh or frozen product to Miami for between $0.18-22 per pound.[25] Details on Salvadoran infrastructure, including utilities, services, labor costs, and transportation can be obtained in an information packet prepared by FUSADES (appendix A).

V. AREA

A. Physical features

El Salvador along with much of Mexico and Central America is one of the most seismologically active regions on earth as it is situated over three tectonic plates. The motions of these plates cause earthquakes and volcanic activity and have played a major role in shaping El Salvador's topography. Two parallel mountain ranges cross El Salvador on an east-west axis. Running along the south of the southern range is the narrow Pacific lowlands coastal plain and between the two ranges is a central plateau. The mountains divide the country into two distinct physiographic regions, 1) the mountains and central plateau comprising 85 percent of the country's area and 2) the Pacific coastal lowlands which make up the remaining 15 percent. The southern mountain range is really a discontinuous chain of more than 20 volcanoes clustered in five groups. The western-most group near the Guatemalan border includes Izalco and Santa Ana, which at 2,365 meters (m) is the highest elevation in El Salvador. Between the cones lie alluvial basins and rolling hills eroded from ash deposits. The rich volcanic soil in this area supports some highly productive coffee farms.

The Pacific lowlands is a coastal plain which in some areas is very narrow. It extends from the southern volcanic range south to the Pacific Ocean. The plain ranges from 1-32 km in width. The coastal plain is widest in the east adjacent to the Golfo de Fonseca. Near Libertad (map), however, the southern mountain range approach the coast and the slope of adjacent volcanoes extends down directly into

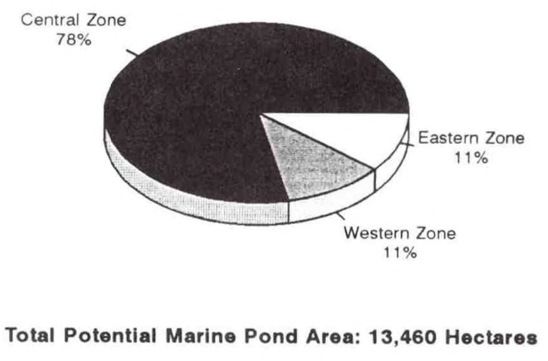

Figure 2.--El Salvador. Most potential shrimp pond sites are in the central zone.

the ocean. Terrain in the Pacific lowlands are generally flat or gently rolling hills formed by alluvial deposits from nearby slopes.

El Salvador has over 300, mostly small rivers. The most important is the Río Lempa which originates in central Guatemala. After entering El Salvador, the Lempa cuts across the northern mountain range and drains the central valley by traversing the southern range and finally emptying into the Pacific through the Jiquilisco estuary. It is the Lempa which feeds the important estuary system in the country's central zone which most observers believe will the major center for the shrimp culture industry (appendices E1-2 and figure 2). The Lempa is the country's only navigable river and its tributaries drain almost half the country. Other Salvadoran rivers are short and mostly drain small localized areas of the central plateau through gaps in the southern volcano range.

B. Farm sites

1. Marine culture

El Salvador has a 330 km coast. The potential area suitable for pond construction is limited by the narrow coastal plain, which in many areas leaves only a small area of level terrain. Only a slight rise in altitude is sufficient to make a site uneconomical because of the excessive water lift required, raising operating costs.[26] Mangrove forestry covers an area of about 35,200 hectares (ha), primarily located in the major estuaries (Jaltepeque, Jiquilisco, and the Golfo de Fonseca). The Government has set the estuaries aside as important nursery habitat for shrimp and other wild aquatic resources. Many excellent sites for marine shrimp farms border the mangrove areas in the three major and more than a dozen smaller estuaries. One assessment suggests that the sandy soils common in the Jaltepeque estuary, however, may preclude the development of potential shrimp culture sites.[27] Despite this limitation, sites with suitable soils exist in the other major areas.[28] Some sources stress in particular the high quality, unpolluted water available to growers at many sites.[29]

Various groups have estimated the area suitable for marine shrimp culture in El Salvador. The estimates range from 8,000 to 24,000 hectares. One U.S. consultant estimated that the country had 15,000-20,000 ha that could be used for shrimp farming.[30] Another consulting group estimated in 1988 that nearly 13,500 ha of land were suitable for pond construction (appendix E1), but the estimate included a substantial area in and near salt pans (appendix E2).[31] Other observers, however, believe that potential sites probably do not exceed 8,000 hectares.[32] One U.S. observer estimated in 1990 that the potential area may be only about 6,000 hectares.[33] The private foundation promoting the industry (FUSADES) currently is advising potential investors that sites exist for about 8,100 ha of ponds (appendix E3).[34]

The greatest area of potential sites is located along the central coast.[35] The central area around the Bahía de Jiquilisco is the single most important area (appendices E1-3). Other areas along both the eastern and western coast offer substantial numbers of suitable sites. FUSADES has conducted an aerial

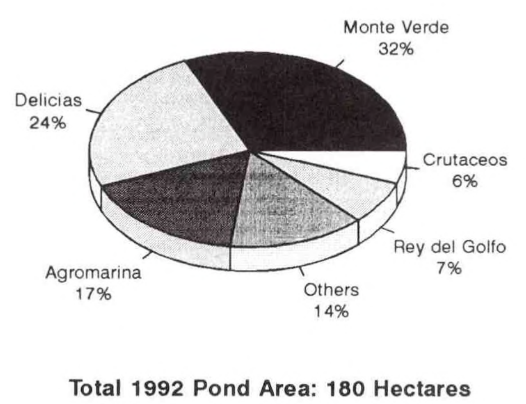

Figure 3.--El Salvador. Only 180 hectares of ponds have been constructed in El Salvador.

survey of the entire coast.[36] Prospective investors can examine these photographs to select appropriate areas for detailed on the ground site inspections.[37]

Growers have developed only a fraction of the potential area. Investors have built about 180 ha of both marine and freshwater ponds (appendix C4 and figure 3). This is a mere 2 percent of the area available, even using the conservative FUSADES pond area estimates. Almost all of El Salvador's existing ponds are relatively new. Growers had constructed only 50 ha of shrimp ponds as recently as 1987 (appendix C5 and figure 4). Growers doubled pond area to 100 ha in 1988, and expanded again in 1989 to about 160 hectares.[38] The active pond area, however, declined during 1990-91 because two major farms, **Monteverde** and **Rey del Golfo** closed due to mounting financial problems. Both these sites are now for sale.[39] FUSADES reports in mid-1992 that six new projects are being planned, two in the eastern zone (Golfo de Fonseca), three in the central zone (Bahía de Jiquilisco), and one in the western zone (Sonsonate Department).[40]

The currently functioning farms are all located in western El Salvador. This primarily reflects the fact that the western area of the country was more secure and thus investors were able to initiate operations during the civil war period.[41] Climatic conditions are quite similar in the three areas as El Salvador is a small country. Some differences, however, exist concerning water intake. Farms in eastern El Salvador have access to estuarine water from the Golfo de Fonseca while some farms in central and western El salvador may be more affected by the annual dry season and will have to engineer direct pumping of oceanic water.[42]

Farms in El Salvador (appendix C1-4) are much smaller than in most other Latin American countries. The largest Salvadoran farm, Agropecuaria las Delicias, currently has only about 60 ha of ponds. This compares with farms in Ecuador, Honduras, and other countries which can exceed 500 hectares. The limited area available and the country's land reform legislation mean that Salvadoran farms will tend to be relatively small. As a result, potential growers have focused primarily on semi-intensive and intensive systems to make maximum use of the available land area (appendix C4). It is unclear how this limitation will affect production costs and the ability of Salvadoran growers to compete with larger farms in other Latin American countries.

Future pond construction plans are unknown. The serious economic problems faced by El Salvador are largely the result of a decade of civil war.[43] The current peace process is encouraging, but the economy has been devastated by the war and the political situation is unsettled. Six groups are known to be currently planning to construct ponds. Pond area could total about 400 ha by 1993 (appendix C5). It is likely that pond construction will proceed, but it is difficult to project until the results achieved by the currently operating farms are better known. Pond area may not exceed 2,000 ha by the year 2000. FUSADES is trying to promote a more rapid expansion of the industry. Some observers are optimistic that the FUSADES promotional program will enable growers to increase the pace of pond construction. This may well prove to be the case, especially if economic conditions improve. Given the limited number of active farms and recent farm closures, however, some caution seems justified.

2. Freshwater culture

Little information is available on potential freshwater sites. One estimate puts the area suitable for freshwater shrimp culture at 500-1,000 hectares. Another observer estimates about 600 ha of suitable sites exist.[44] One consultant indicates that a tilapia farm near Nuevo Concepción could be converted for freshwater shrimp. The same consultant also identified about 500 ha of cattle grazing land near the Río Ceniza, the flatlands bordering Embalse Cerron Grande, and sites near Caedalera de la Frontera as being appropriate for freshwater shrimp culture.[45]

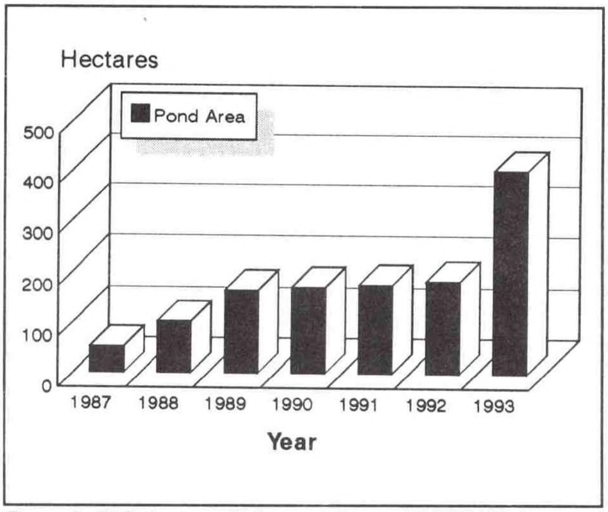

Figure 4.--El Salvador. Shrimp pond area has steadily increased since 1987.

Growers have actually built a very small area of ponds (appendix C5). Observers vary somewhat on the precise area. One report suggests that less than 15 ha of ponds have actually been constructed. FUSADES roughly confirms that estimate and reports that slightly over 20 ha are currently in operation.[46]

VI. CLIMATE

El Salvador has a tropical climate with pronounced rainy and dry seasons. **Temperatures** are primarily determined by altitude and exhibit little seasonal variation. The Pacific lowlands are the warmest region with annual average temperatures ranging from 25-29°C. **Precipitation** is seasonal with a rainy season (winter/invierno) from May to October. Almost all of the country's rainfall occurs during this period. Annual totals, especially on southern facing mountain slopes can be as high as 200 centimeters (cm). Rainfall during the rainy season generally comes from low pressure over the Pacific and usually falls in heavy afternoon thunder showers. Hurricanes occasionally occur in the Pacific, but seldom affect El Salvador. From November through April (summer/verano), northeast trade winds control weather patterns. During these months, air flowing from the Caribbean has had most of the precipitation wrung out of it while passing over Honduran mountains. By the time it reaches El Salvador, the air is dry, hot, and hazy. As a result, shrimp growers will have to adjust their growout system to accommodate the arid conditions during the summer dry season.

VII. FARMS

A. Marine shrimp

El Salvador in early 1992 had five marine shrimp farms. Only two of the farms were operating, both semi-intensive operations. Several farms have closed in recent years.[47] The authors do not have details on those closures. Several of the early farms were poorly designed. Some appear to have had seasonal difficulty obtaining postlarval seedstock, but FUSADES reports that current growers have no difficulty obtaining postlarvae (pl).[48] One source reports that two relatively large farms closed during 1991 because of financial problems, but did not provide details. A new intensive farm is under construction (appendix C3).

Acuisal: The farm reportedly closed in 1990. It also operated the Surge hatchery.

Agromarina de El Salvador: Agromarina is a \$0.5 million project located at los Cobanos, about a 1½-2 hour drive west from San Salvador. The company reports operating 27 ha of irregularly shaped semi-intensive ponds. Another report suggests 30.5 ha of ponds, including the nursery ponds (appendix C4).[49] The eight growout ponds average 3.4 ha, ranging from 1.5-7.0 hectares. It has recently undergone a major renovation with FUSADES assistance to improve the water pumping and distribution system. The FUSADES sponsored-technical team recommended that the farm be operated on a semi-intensive system because of water limitations and other characteristics of the site.[50] The farm is currently being stocked at an average 8 pl per m^2 (ranging from 5-15 pl per m^2) with wild collected *P. vannamei* and *P. stylirostris*. In the first cycle only four ponds were stocked, but all eight ponds were stocked in the second cycle. The company reported a total 1991 harvest of 35 t, with an yield of about 1.3 t per ha per crop.[51] On an annualized basis this would probably be about 2.6 t per hectare.[52] Farm managers are convinced they can achieve substantially higher results in 1992 because the renovations which impaired 1991 operations have been completed.[53]

Agropecuaria Las Delicias: A new 60-ha intensive farm is currently under construction at a site near the Guatemalan border with technical assistance through the FUSADES program.[54] Unlike the other two FUSADES farm projects which involved renovating existing farms, the Delicias farm was coordinated by the FUSADES team from site selection to farm design and construction. The project is proceeding in two phases. The first phase is nearing construction and should be in production by late 1992. The 2-ha rectangular ponds are equipped with paddle-wheel aerators. The company hopes that after initial start-up runs they will be able to achieve yields of 6-8 t per year.[55] Planned stocking densities are from 35-70 pl per m^2.[56] The technical team advising the owner is convinced that with good management, even higher yields can be achieved.

Crustaceos del Pacífico: Crustaceos del Pacífico is located along side of the Agromarina farm at los Cobanos. The farm was built for more intensive operations than Agromarina and consists of 10

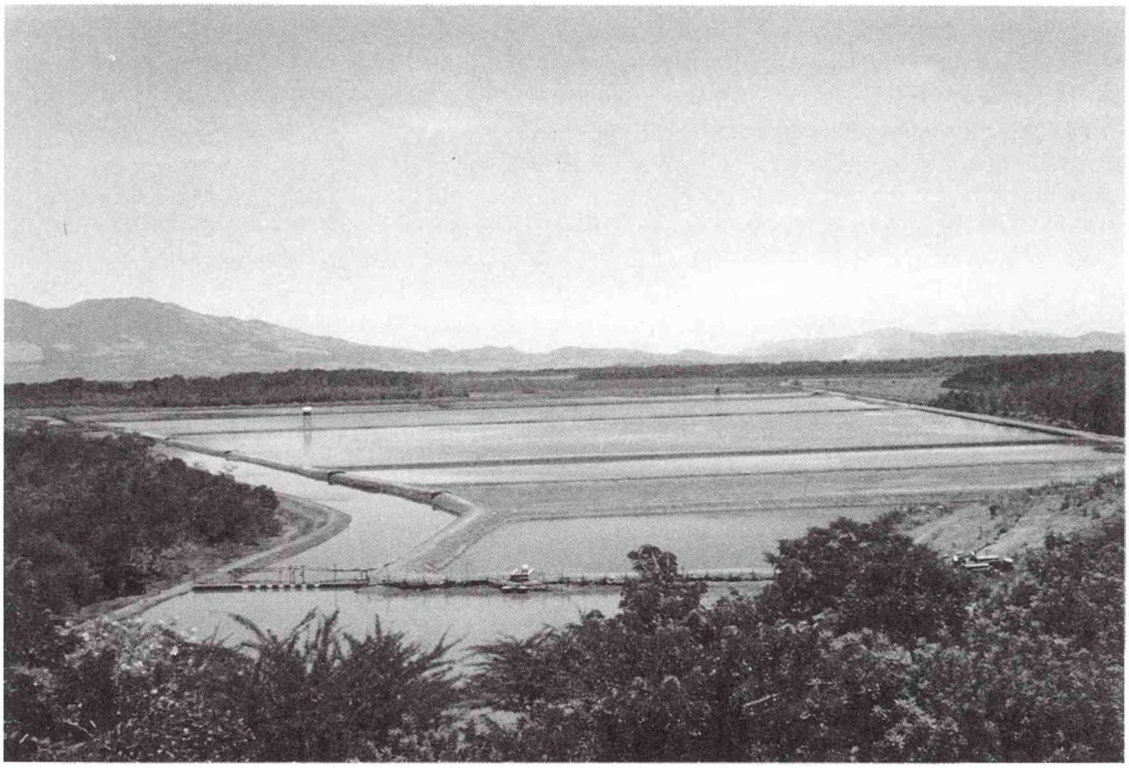

Photo 1.--*El Salvador. One of the two operating shrimp farms in El Salvador as of mid-1992. © RDA*

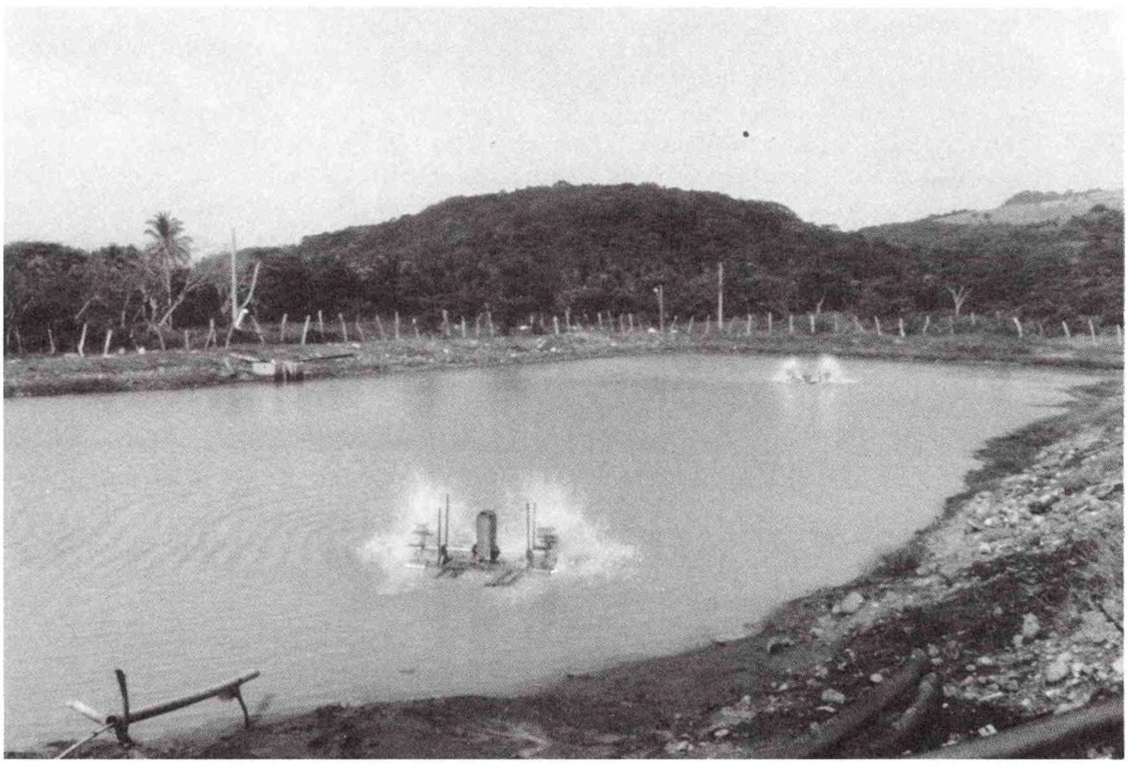

Photo 2.-- *El Salvador. Growers are building small ponds with intensive modifications because of the limited pond area. © RDA*

uniform, rectangular ponds of about 0.8 ha each.[57] Each pond has an electrical supply to power one or more 1-hp paddle-wheel aerators. The farm had been closed for some time, but was recently reopened with FUSADES technical assistance. The company decided to operate the ponds on a semi-intensive basis for the first production cycle and stocked at 10 pl per m^2. The results will determine planned efforts to intensify growout strategy.[58] The company reported a total harvest of 11 t in 1991, with an annual yield of 1.1 t per hectare.[59] Another report suggests a much higher yield of 1.7 t per crop.[60] On an annualized basis this would probably be about 3.4 t per hectare.

Cultivos Agroindustriales: This farm has closed.

Hermanas Penado Alvarado: This farm has closed.

(El) Porvenir: New farm project which has obtained a loan approval through FUSADES.

Promotora Puerto Arturo: This farm has closed, but FUSADES is reportedly studying a project to renovate the facility.

Rey del Golfo: This farm has closed.

Sociedad Monte Verde: This farm has closed.

Other projects: Some other marine farms have been built, but are not currently operating. Information on the status of the closed farms is unavailable. One report suggests that at least three new projects with a pond area totaling about 200 ha are currently in the design phase. Another observer indicated during mid-1992 that six new projects are underway, but did not specify the pond area involved.[61]

B. Freshwater Shrimp

Several private groups are operating small freshwater shrimp farms. Few details are available, however, on these small operations. The growers have reported little real commercial success.

FUSADES sponsored a small freshwater shrimp pilot project in 1988 with technical support from the Hawaii Aquaculture Company, renovating an old tilapia farm at Santa Ana. The ponds were built by hand and an above the ground nursery facility converted for use as a *Macrobrachium* hatchery.[62] Eight ponds totaling 2.9 ha were renovated. Two crops were harvested from May 1989 to August 1991. The farms were managed with a semi-intensive system using some aeration. The annual yields totaled 3.0 t per ha, although FUSADES is using what they call a "discounted" yield of 2.4 t per hectare.[63]

FUSADES followed the Santa Ana project with growout assistance and hatchery demonstration projects. Nearly 10 private growers and cooperatives are currently farming freshwater shrimp, but they operate a very small area of ponds. One report suggests the pond area involved is less than 15 ha (appendix C4) and another observer gives a slightly higher estimate of 20 hectares.[64] The largest farms are **Palo Combo** (5 ha) **Singuil** (4 ha), **San Francisco Guajoyo** (3 ha), and **Zontemar** (2 ha).[65] Another small farm, **Mariscos Capricornico** (2 ha), was active in 1991, but may now be closed. Available details on individual farms suggest that a wide range of growout systems are used. One report indicates they some growers use high-density nurseries, size grading, and other advanced methods while others use lower stocking densities and more basic methods.[66]

VIII. HARVESTS

Available data suggests that shrimp growers harvested an average of about 40-50 t annually between 1985-88.[67] Growers reported a small increase in 1989 with a harvest of 60 t and another increase to about 90 t in 1990.[68] The 1991 harvest was only around 46 t, however, because of the closure of the Monteverde and Rey del Golfo farms (appendix B1

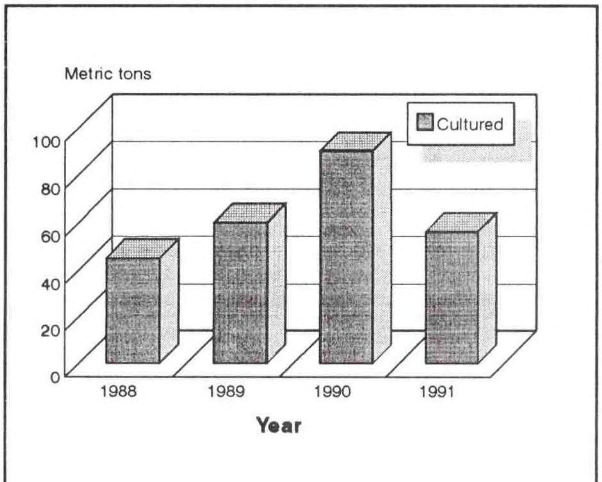

Figure 5.–El Salvador. Shrimp harvests remain small, only about 50 tons in 1991.

and figure 5). Local observers are projecting a substantial increase in the 1992 harvest as a result of expanded harvests at Agromarina and Crustaceos del Pacífico. las Delicias will probably begin operations in late 1992, but will probably not report significant harvests until 1993.

The unsettled economic conditions make it difficult to project future harvests. The two operating farms are reporting impressive yields. The technical assistance, fiscal incentives, and credit program is attracting some investor interest. Almost certainly growers will be able to significantly expand harvests during the 1990s. Harvests of 3,000-4,000 t by the year 2000 seem plausible. If the yield estimates projected by FUSADES prove accurate, the industry may expand even more rapidly. The full potential of the industry is substantial, but the industry's growth will in part depend on the Government's success in addressing the country's massive economic problems.[69]

Growers operated two small freshwater farms in 1989 with a total pond area of only 4 hectares.[70] The 1989 harvest was about 3 t (appendix B1). The harvest continues at small levels, but growers reported a small increase in 1991, harvesting almost 10 tons.[71] Another report suggests that nine freshwater farms are active in 1992, but information is only available on four farms (appendix C4). Some growers have reportedly tried to culture both marine and freshwater species.[72]

IX. YIELDS AND PRODUCTION COSTS

A. Marine

El Salvador's two currently active shrimp farms are reporting excellent yields. The two farms are achieving annual yields of about 2.6-3.4 t per ha based on a calculation of two harvests per year. (See section VII. Farms.) These are fairly impressive figures given the fact that both have only recently begun growout operations in their renovated facilities. Slightly higher annual yields of 3.0-3.9 would result from the 2.3 harvests per year FUSADES believes possible. It is likely that both farms will report improved results in 1992 and 1993.

The FUSADES shrimp culture assistance team estimates that shrimp can be produced for about \$2.85-3.50 per kilogram (kg) in El Salvador. FUSADES reports that the estimated returns on farms of 20-40 ha are quite attractive and that farms as small as 10 ha can prove profitable. FUSADES estimates are based on interest rates of 15.5-16.0 percent, small (1-2 ha) ponds, pl costs of about \$9 per 1,000, feed at \$0.70 per kg, achieving 2.2-2.3 crops per year, harvesting 19 gm shrimp (36-40 count, tails per pound), feed conversion rates of 2.1:1, and yields of about 5.3 t per hectare.[73] The FUSADES yield estimate would appear somewhat high, especially during the industry's start-up phase. The initial results reported by Agromarina and Crustaceos suggest that the FUSADES technical team is helping growers achieve impressive results even in start up operations, but not yet close to the 5.3 t per ha that FUSADES believes possible. The new Delicias project which has been completely designed by FUSADES may achieve even better results. Whether it can achieve the 5.3 t yield level remains to be seen.

It is unclear how the limitations on farm size will affect Salvadoran growers. Clearly farms of 10-50 ha will not benefit from the economies of scale achieved by some of the large farms in Colombia, Ecuador, Honduras, and other countries. It will be more costly to purchase feed and other supplies in small quantities. Contracting technical assistance and shipping small consignments may prove especially costly. Other basic costs of doing business are likely to be much higher for small operations. Such problems could result in elevated production costs. The general experience in Latin America has been that operating extremely small farms has not proven profitable. Actual results will depend heavily on whether intensive operations prove competitive with semi-intensive and extensive farms in other countries. It is much more critical to maintain factors such as temperature, salinity, water quality, feed schedules, etc. at intensive farms. As a result, small management units may prove more effective in such operations.

B. Freshwater

The FUSADES demonstration project achieved annual yields of 3 t of freshwater shrimp per hectare.[74] No information is available on actual yields being achieved by the small number of individual growers. FUSADES reports that 4-15 count shrimp (individuals per pound) can be exported for \$11.00-15.40 per kilogram. Shrimp counts above 15 are sold locally for \$5.50 per kilogram. With these yields and prices, FUSADES is convinced that freshwater shrimp culture will prove profitable and cites marketing studies to confirm this.[75] The absence of a single commercially successful farm, however, means that the feasibility is yet to be demonstrated.

X. PROCESSING INDUSTRY

El Salvador has a small shrimp processing industry to support its capture fishery. About 14 processing plants are currently active with the capacity to process about 35 t of shrimp daily. Several of the processing plants report operating substantially below capacity because of the declining trawler catch. (See Section I. Capture Fishery.) The capacity far exceeds the current catches being landed in El Salvador and as a result several plants operate only part of the day.[76] Some plants no longer process shrimp at all. Important processing companies are located in Acajutla, La Libertad, La Unión, and Puerto El Triunfo (appendix F). The industry's cold storage capacity is 2,000 t and the companies can produce about 155 t of ice daily. Some packers, including Picis are already studying the possibility of processing the projected harvests of shrimp growers.[77] The plants primarily pack 5 pound boxes of frozen tails, but many can also process heads-on, peeled and deveined (P&D), PUD, butterfly, and individually quick frozen (IQF) shrimp.[78]

XI. FEED

Some observers report that feed price and quality are a problem. Several of the farms now closed experienced problems with formulating and preparing feed because until recently a balanced shrimp feed was not produced in El Salvador.[79] Most feed is currently imported from **Ralston Purina** in Guatemala. Imports are feasible from Guatemala because the currently operating farms are located in the western part of the country close to the Guatemalan border. One local animal feed producer, **Tec-Nutral**, has begun to produce a shrimp ration under the direction of **Hawaii Aquaculture**.[80] The company has the potential to produce about 400 t of feed per month.[81] Feed costs are reportedly about $0.70 per kilogram.[82] The authors know of no other Salvadoran company producing shrimp feed. Observers report that feed prices and quality may become a more serious concern as growers attempt to intensify operations. The Centro de Desarrollo Pesquero (CENDEPESCA), El Salvador's fisheries agency, for example, reports that the lack of a high quality feed producer is impairing the development of the country's shrimp culture industry.[83] Several companies are currently studying the possibility of producing shrimp feed.[84]

XII. EXPORTS

A. Marine shrimp

Almost all of El Salvador's shrimp, both cultured and wild caught, is exported. Salvadoran domestic consumption of shrimp is very low. Export shipments reached a peak of 3,900 t in 1984, but have since declined to only 2,100 t (appendix G1). Both 1990 and 1991 have been particularly poor years and the industry is experiencing a very difficult financial crisis. The problem is primarily the decline of the capture fishery, but the reasons for the declining catch are not well understood. (See Section I. Capture Fishery.)

Shrimp shipments are almost entirely to the United States.[85] Exports to the European Community (EC) and Japan are negligible (appendix G1), but at least one company (Agromarina) made trial shipments to Portugal during 1991. U.S. 1991 imports from El Salvador totaled 2,100 t, a slight decline from the 2,400 t imported in 1990 (appendix G2 and figure 6). Salvadoran imports to the United States averaged 2,900 t between 1985-91.[86]

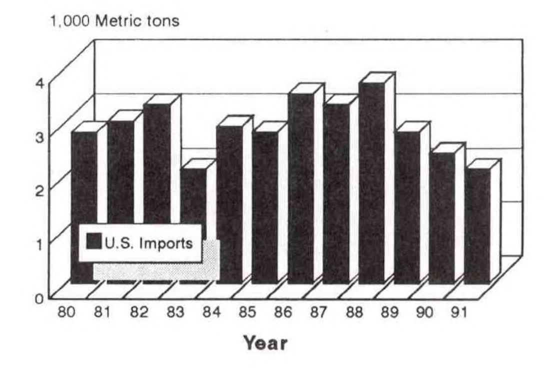

Figure 6.--El Salvador. Shrimp exports to the United States have declined since 1988.

B. Freshwater shrimp

Some observers believe that El Salvador could develop a small trade in freshwater shrimp. Early results, however, have not been encouraging. One feasibility study conducted by RDA in 1988 was generally negative about the prospects for freshwater shrimp exports.[87] More recently, another group working with FUSADES reports, however, successful test marketing trials. Existing air freight connections could be used to deliver fresh, whole freshwater shrimp to the U.S. market.[88] While many Latin American groups have experienced difficulty marketing freshwater shrimp, one consultant is convinced that it is feasible, but suggests that marketing efforts should target end-users.[89] The lack of significant Salvadoran harvests and an established trade, however, suggests that potential U.S. investors should be cautious.

XIII. POSTLARVAL SUPPLY

A. Marine

Growers currently rely entirely on pl collected by artisanal fishermen when available in local mangrove estuaries. Some observers believe the Salvadoran estuarine system to be one of the richest in Central America.[90] FUSADES reports that growers currently have no difficulty obtaining postlarvae.[91] Artisanal fishermen are benefiting from the substantial availability of wild pl by selling to the small number of Salvadoran growers and more importantly to the rapidly expanding number of growers in neighboring Honduras where the industry has developed significantly in recent years.[92] One estimate suggests that enough pl could be collected in El Salvador to stock 5,000 ha of ponds or 1 billion postlarvae.[93] Other observers insist that the quantity of pl which can be collected by artisanal fishermen on a sustainable basis is simply unknown. CENDEPESCA is concerned about the collection of pl because of the possible impact on wild stocks.[94] The authors have no information on the seasonality of pl abundance.

FUSADES is sponsoring a detailed study of the pl resource which may be one of the most comprehensive assessment compiled by any Latin American country.[95] The study will evaluate both the quantity of pl which can be collected and the impact on the ecosystem. FUSADES indicates that preliminary findings have identified four areas where pl can be collected.[96] Presumably the FUSADES study will also provide information on seasonal fluctuations.

A major Salvadoran shrimp culture industry will require significantly higher pl production. Artisanal collectors are currently capable of fully supplying the small number of Salvadoran farms, but may have difficulty finding pl during the dry season. Local observers believe that the industry will eventually have to turn to hatcheries to guarantee the reliable availability of postlarvae. One group believes that the country's largely undeveloped coast offers many suitable sites for shrimp hatcheries with high-quality water.[97] Several small hatcheries have been built in El Salvador (appendix D and figure 7). There are no commercial-scale hatcheries currently in operation, but one is currently under construction.

Oceanica: The country's first important hatchery is Oceanica, which is scheduled to open in mid-1992.[98] Oceanica is a modern *Penaeid* hatchery designed to produce 5-6 million pl monthly. Current pl demand from the small number of Salvadoran farms will not support the hatchery, especially when wild pl is available. FUSADES foresees a rapid increase in demand as a result of the projected expansion of pond area (appendix C5). Oceanica plans to both supply domestic growers and to export to growers in other countries.[99]

B. Freshwater

Salvadoran growers are using an exotic species, *M. rosenbergii*. As a result there are no available wild stocks to source for seedstock. Pl for the initial stage

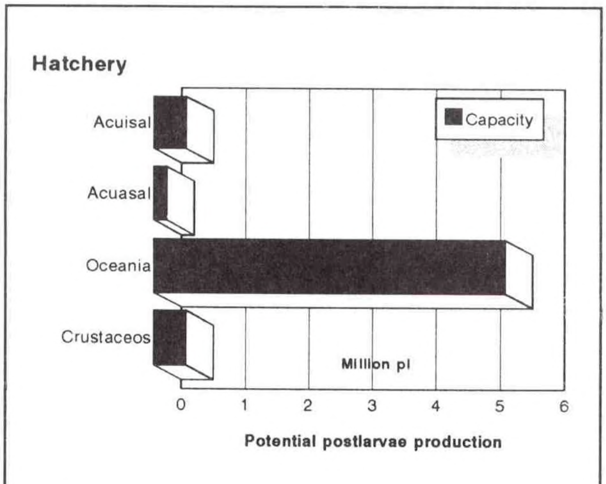

Figure 7.--El Salvador. The potential for postlarvae production is low, but should increase as more hatcheries begin operation.

of the industry's development was imported from hatcheries in Costa Rica, Guadeloupe, and Puerto Rico.[100] Three small hatcheries produce limited quantities of pl, although some reports suggest that most are currently closed (appendix D).

Surge: One of the most important hatchery projects was the Surge hatchery operated by Acuisal. It was built in 1983 at Quezaltepeque, La Libertad and was the country's first commercial freshwater shrimp hatchery. The company used pl from a Panamanian hatchery and sought to produce about 3 million pl annually for small-scale growers.[101] The Surge hatchery is reportedly closed.

Izalco: The Government also produced small quantities of freshwater shrimp pl at the Izalco aquaculture station, but later transferred the operation to the El Zope aquaculture station near the port of Acajutla where seawater is available.[102]

El Zope: CENDEPESCA with assistance from the Taiwan Government opened a freshwater shrimp hatchery in 1990 at the Estación de Maricultura El Zope. The hatchery is reportedly working with both *M. rosenbergii* as well as *Penaeid* species.[103]

Postlarval seedstock are reportedly available for about $15-20 per 1,000 postlarvae. Economic cost analysis made by FUSADES suggests that the profitability of freshwater farms are not significantly sensitive to pl prices.[104]

XIV. GOVERNMENT ROLE

The Government has played a limited role in the development of the shrimp culture industry. The Salvadoran fisheries agency, CENDEPESCA, which is part of the Ministerio de Agricultura y Ganaderia, has since the mid-1970s conducted limited efforts to promote shrimp culture.[105] Few investors, however, made commitments to the new industry. The Government has since 1989 implemented macro-economic policies which are creating a favorable business climate and attracting increasing investor interest.[106] The Government passed the "Foreign Investment Promotion and Guarantee Law" in 1989 which provided investor safeguards. The Government subsequently passed the "Exports Reactivization Law" in 1990 which provided further inducements. The Government incentives are designed to promote the development of non-traditional exports such as cultured shrimp. Incentives include tax holidays, easier access to export certificates,[107] and tariff exemptions on the importation of machinery, equipment, and other needed items.[108] Export oriented businesses can be fully foreign owned and investors have favorable conditions for maintaining hard currency accounts, converting export earnings, and repatriating profits. In addition, exporters receive a bonus on export earnings returned to El Salvador.[109] Additional inducements include the availability of credit at favorable terms. (See Section XVI. Credit) While many observers are hopeful that the current peace process will resolve the country's bitter civil war, given the country's history, the long term outcome is not yet determined. As part of the effort to attract investors, the Government insures investors against loss due to civil disorders.[110] Details on export investment incentives are available from FUSADES (appendix A).

The Salvadoran Government's preoccupation with the 12-year civil war made it difficult to direct resources to emerging industries such as shrimp culture. The peaceful resolution of the conflict may allow the Government to focus on economic problems. The FUSADES promotion program is viewed by some as the best designed shrimp culture development effort in Central America. Some observers are optimistic about the overall economy.[111] Economic conditions in war-torn El Salvador, however, continue to be difficult. The country has massive economic and social problems to address with very limited resources. The political situation continues unsettled.[112] As a result, CENDEPESCA's participation in the industry will probably continue to be restricted by very limited budget allocations.

XV. LEGAL FRAMEWORK

Various Government agencies enforce laws affecting the aquaculture industry. One legal provision of particular importance to shrimp growers is a law regulating the use of coastal salt flats and estuarine areas.[113] The law is enforced by the Centro de Recursos Naturales through its Servicio Forestal y de Fauna. The other major legal structure is the country's principal fisheries law and supporting regulations administered by CENDEPESCA.[114] The Government offers 10-year concessions for shrimp growers which can be renewed for 10-year periods. Growers have to obtain authorization for their project from CENDEPESCA which reviews all aquaculture enterprises. The law permits both Salvadoran citizens and foreigners resident in El Salvador to engage in aquaculture.[115] The country's land reform law also presents some constraints, limiting the size of land holdings.

XVI. CREDIT

Obtaining investment capital has been one of the most difficult problems faced by Salvadoran growers. Few investors were willing to commit funds, especially in rural areas, during the 1980s as a result of the protracted civil war. The Government made it even more difficult for potential growers to obtain needed investment funds by maintaining a tight credit policy designed to control inflation. The resulting credit shortage severely impaired the industry's development.

The resolution of the civil war may lead to increased domestic and foreign investment and an increase in shrimp pond construction. The impact, however, is unclear at this time because of the still unsettled economic and political situation.[116] Some recent developments are encouraging. The Salvadoran investment law is much less restrictive than many other Latin American countries. The Government has removed barriers discouraging foreign investment, giving foreign investors the same rights as nationals. El Salvador permits 100 percent foreign ownership and full repatriation of profits.[117]

Several credit lines are available to shrimp growers. The Fundación Salvadoreña para el Desarrollo Económico y Social (FUSADES) offers assistance to private groups. FUSADES acts through its Programa de Diversificación Agricola (DIVAGRO) and Export Investment Fund (FIDEX) units to provide long-term aquaculture loans at favorable terms.[118] FIDEX will fund up to 80 percent of capital costs and 60-90 percent of operating costs. Repayment can be made over a 5-10 year period with a 1-2 year grace period. Investors benefit from a 10-year tax holiday.[119] The U.S. Agency for International Development (AID) has provided $10 million in credit for aquaculture development. FUSADES has approved loans for two new shrimp farms, El Porvenir and Las Delicias, and is analyzing a third project, Puerto Arturo. AID has also provided loans and technical assistance to cooperatives.[120]

XVII. TECHNICAL CAPABILITY

El Salvador has a very limited technical capability in shrimp culture. CENDEPESCA initiated some basic work on both freshwater shrimp (1972) and marine shrimp (1978).[121] It continues some shrimp culture research, but the overall effort has been very limited.[122] CENDEPESCA research work has been conducted at the agency's aquaculture stations (Izalco, Santa Cruz Porrillo, and El Zope). The El Zope station has a small hatchery and 2.6 ha of experimental growout ponds.[123] Salvadoran universities have done little work on aquaculture and almost no work on shrimp culture. CENDEPESCA hopes, however, to initiate a scientific support program for shrimp culture ("Apoyo al Desarrollo de Cultivo de Camarón en El Salvador"). The program will provide training for technicians in shrimp hatchery and growout methods. The agency so far, however, has been unable to begin the program due to budgetary constraints.

The country's limited technical capability with shrimp culture is a major factor inhibiting the industry's development. CENDEPESCA itself recognizes its limited capability and the inexperience of investor groups with aquaculture as a major factor impairing the industry's development.[124] The private Salvadoran Foundation for Economic and Social Development (FUSADES) has contracted with three U.S. consulting firms to provided needed technical assistance to shrimp growers. The three companies (Hawaii Aquaculture Company, Research Planning Inc., and Aquatic Resources International) have prepared a well-coordinated development program for the industry. The group offers hands-on technical assistance and extension services. Assistance is available from preliminary feasibility studies, through project design and growout operations to export marketing assistance. An in-country team, supported by highly-qualified technical experts in both El Salvador and the United States, provides access to state of the art technology.[125]

Commercial aquaculture is a new industry in El Salvador and as a result relatively few Salvadorans have pursued training courses and academic degrees. FUSADES recognizes the importance, however, for developing a domestic technical capability. FUSADES has sponsored the training of 26 technicians in South Carolina. In addition some Salvadorans now have degrees awarded by Auburn, Louisiana State University, and Texas A&M.[126]

CENDEPESCA eventually hopes to provide technical assistance through its aquaculture research centers and has developed plans to train staff.[127] Prospects for such a program, however, are not good. Elsewhere in Latin American, government fishery research institutes have had difficulty retaining qualified staff because such personnel, once trained, are able to command high salaries in the private sector.

XVIII. FOREIGN ASSISTANCE

The principal country assisting El Salvador develop its shrimp culture industry is the United States. This assistance has been provided by U.S. AID and the consulting companies contracted by FUSADES. Several other foreign groups, however, offer limited assistance to El Salvador's shrimp culture industry. The Taiwanese Mission provides advisors for the CENDEPESCA experimental aquaculture station at El Zope.[128] The EC partially finances the Programa Regional de Apoyo al Desarrollo de la Pesca (PRADEPESCA), which is coordinated by the Organización Latinoamericano para el Desarrollo Pesquero (OLDEPESCA). This project operates a regional marine and freshwater shrimp culture project focusing on both hatchery and growout work.[129]

XIX. OUTLOOK

El Salvador has the potential to develop a small shrimp culture industry. Many excellent sites exist. The climate is appropriate for both freshwater and marine shrimp culture. The country has abundant freshwater resources. Extensive stretches of the coast are largely undeveloped and many unpolluted sites exist. Substantial quantities of postlarval seedstock are available in local estuaries and a modern new hatchery is scheduled to open in late 1992. Salvadoran growers may benefit from the availability of technical expertise and experience, as well as the growing support industries in neighboring Guatemala and Honduras. A variety of problems, however, have impeded development. The 12-year civil war discouraged investment in pond construction during the 1980s. Investment credits were difficult to obtain. As a result, only two Salvadoran growers in mid 1992 were operating shrimp farms. Government officials believe the industry, however, to be a promising medium-term fishery investment opportunity. FUSADES is addressing some of the problems which have impeded the industry's development, including difficulties securing credit and a lack of technical knowledge. Government credits and a supportive technical assistance program is attracting increasing interest among investor groups. The Government's overall economic and fiscal policies appear attractive to foreign investors. Growers have developed only a fraction of the potential area suitable for culture, and harvests are small--only about 50 t in 1991. Current trends suggest that the industry will expand during the 1990s and because of the extremely small current harvests, the industry could report a very rapid growth rate. A harvest of 3,000-4,000 t by 2000 seems plausible, although the country's full potential may be much larger.

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World Shrimp Farming, various issues.

ENDNOTES

SECTION I (Capture Fishery)

1. The Salvadoran Centro de Desarrollo Pesquero (CENDEPESCA) will restrict the number of shrimp licenses issued in an effort to reduce the number of shrimp trawlers from 90 to 60 vessels by 1993. Rolf Juhl, NMFS, personal communications, April 30, 1992.

2. George B. Gross, "Shrimp Industry of Central America, Caribbean Sea, and Northern South America," Foreign Fisheries Leaflet No. 73-1, National Marine Fisheries Service, 1973.

3. FAO, *Yearbook of Fishery Statistics*, 1989.

4. Dennis Weidner, "Salvadoran Shrimp Fishermen Report Difficulties," *International Fishery Report*, (IFR/92-23) March 3, 1992.

5. FAO, Fishery Country Profile, January 1986 and Juhl, *op. cit.*

6. Dennis Weidner, "Honduran Shrimp Culture," *International Fishery Reports*, (IFR-91/21) March 29, 1991.

SECTION II (Species)

7. FAO statistics show a much larger 1989 harvest of *P. stylirostris* than *P. vannamei.* No. 815, Revision 3, FAO "Aquaculture Production 1986-89," FAO Fisheries Circular, July 1991.

8. Tom Revord and Dennis Weidner, "Ecuadorean Shrimp Culture," *International Fishery Reports* (IFR-92/19), February 28, 1992.

9. For details see Dennis Weidner and Tom Revord, "Panama Shrimp Culture," *International Fishery Reports*, (IFR-91/94), December 27, 1991 and Weidner, "Honduran Shrimp Culture," *op. cit.*

10. See for example J. Ulloa, *Policultivo de camarones Peneidos, P. stylirostris, P. vannamei, y P. californiensis en estanques de agua salobre de estadios juveniles* (Servicio de Recursos Pesqueros, DGRNR-MAG, 1978).

11. U.S. consultant Paul Maugle reports some feed trials which included *P. californiensis*. Paul Maugle, item 13.3.33-35, *Aquaculture Digest*, July 1988, p. 15.

12. Ministerio de Agricultura y Ganaderia, *op. cit.* See for example Sanchez, C. *Embriología del camarón del río Macrobrachium tenellum* (Departamento de Piscícola, DGRNR-MAG: San Salvador, 1972), 6p. and C. Sanchez. *Desarrollo de juveniles del camarón de río Macrobrachium tenellum* (Servicio de Recursos Pesqueros, DGRNR-MAG, 1975).

13. Daniel Cheney, P. de Rito, G. Bonacker, J. Richardson, K. Sackheim, D. Sweat, and D. Wilson, *El Salvador Aquaculture Feasibility Study*, RDA International/FUSADES, 1988, p. 24.

SECTION III (Aquaculture)

14. Ministerio de Agricultura y Ganaderia, Centro de Desarrollo Pesquero. "El Cultivo de Camarón en El Salvador," presented at the Simposio Centroamericano sobre Camarón Cultivado, April 1991, p 1.

15. For details on the project see N.F. Jimenez, "Evaluación del programa: Estanques piscicolas comunales en su primer periodo, 1973-75," *Inf. Tec. Serv. Recur. Pesq.*, Vol. 5, No. 4, 1978, 38 p.

16. A good description of efforts to develop the country's aquaculture industry can be found in G.J.F. Godinez, *Diagnostico de la piscicultura en El Salvador*, (Ministerio de Agricultura y Ganaderia: San Salvador, 1984), 80 p.

17. Cheney, *op. cit.*, p. 3.

18. A good review of El Salvador's aquaculture industry is available in F.C. Abrego and J.L. Salazar, *El estado de la acuicultura en El Salvador a diciembre de 1988* (Projecto Aquila: 1989), GCP-RLA-075-ITA.

19. Cheney, *op. cit.*, p.3.

20. "Fish Farm Helps Displaced Families," *Diario Latino*, October 15, 1983, pp. 4, 19.

21. The FAO report suggests almost all of that production is marine fish, but the authors know of no important marine fish culture activity in El Salvador. FAO, "Aquaculture Production, 1986-89," *op. cit.,* p. 87.

SECTION IV (Infrastructure)

22. One estimate suggests that physical infrastructure (bridges, roads, power lines, communications, etc. will require about $1.6 billion to repair, a massive sum in the small Salvadoran economy. The total cost to the Salvadoran economy has been much higher as considerable repairs were carried out during the conflict. Hugo Juan-Ramón, "El Salvador Starts to Rebuild," *The IDB*, May, 1992, pp. 8-9.

23. Linos Cotsapas, "Resources and Infrastructure for Aquaculture Development in El Salvador," paper delivered at Aquaculture '92, Orlando, Florida, May 24, 1992.

24. Francisco Martinez, FUSADES, "Investment Incentives for Aquaculture Development in El Salvador," paper delivered at Aquaculture '92, Orlando, Florida, May 24, 1992.

25. Jorge Alberto Ramos, Aquaculture Manager, FUSADES, personal communication, June 18, 1992.

SECTION V (Area)

26. aul Maugle, PDM Associates, personal communications, May 24, 1992.

27. Sandifer, Cotsapas, and Malecha, *op. cit.*, p.72.

28. Cotsapas, "Resources and Infrastructure," *op. cit.*

29. Michener, "Shrimp Farming," *op, cut.*

30. Paul Maugle, item 13.3.33, *Aquaculture Digest*, March 1988, p. 18.

31. Cheney, *op. cit.*

32. Bruce Michener, Agribusiness Specialist, U.S. Agency for International Development (AID), San Salvador, personal communications, August 27, 1990.

33. Bruce Michener, "Shrimp Farming in El Salvador," as cited in *World Shrimp Farming*, May 1990, p. 19.

34. Mauro Suazo, Agribusiness Director, FUSADES, personal communication, May 22, 1992.

35. RDA International estimated the total potential area to be 13,460 ha, mostly at the mouth of the Rio Jiboa. This southeastern coast contains a series of estuaries, bays, and marine wetlands.

36. U.S. consultant Cornelius Mock assisted FUSADES with the survey. Joel Kirkpatrick, "El Salvador Targets U.S. Shrimp Lovers," *The Daily News*, May 6, 1988.

37. Paul Sandifer, "Commercial Shrimp Culture in El Salvador: Case Studies," paper delivered at Aquaculture '92, Orlando, Florida, May 24, 1992.

38. One source suggests as much as 200 hectares.

39. Elizabeth MacMichael, Hawaii Aquaculture, personal communications, April 30, 1992.

40. Ramos, *op. cit.*

41. Paul Sandifer, Aquatic Resources International, personal communication, May 24, 1992. CENDEPESCA also reports that hostilities impaired the industry's development in the eastern region of the country. Ministerio de Agricultura y Ganaderia, *op. cit.*, p. 20.

42. Linos Cotsapas, "Resources and Infrastructure for Aquaculture Development in El salvador," paper delivered at Aquaculture '92, Orlando, Florida, May 24, 1992.

43. Juan-Ramón, *op. cit.*, p.8.

44. Cotsapas, "Resources and Infrastructure," *op. cit.*

45. Cheney, *op. cit.*, pp.37-38.

46. Ramos, *op. cit.*

SECTION VII (Farms)

47. Michener, "Shrimp Farming," *op. cit.*

48. Ramos, *op. cit.*

49. Such differences are commonly found in preparing these reports. They usually are caused by trying to integrate information received from a variety of different sources prepared at different times. In this case the difference probably is due to the fact that some sources provide pond surface data only for growout ponds while others may include nursery ponds and or canal surface area.

50. Sandifer, Cotsapas, and Malecha, *op. cit.*, p.75.

51. Sr. Ovando, Manager, Agromarina, personal communications, April 30, 1992.

52. Based on two crops per year.

53. Sandifer, "Commercial Marine Shrimp Culture," *op. cit.*

54. MacMichael, *op. cit.* For information on the small, but growing shrimp culture industry in neighboring Guatemala see Dennis Weidner, "Guatemalan Shrimp Culture," *International Fishery Reports* (IFR-91/92), December 20, 1991.

55. Individual crops of 3-4 t are projected with about two harvests annually. Sandifer, Cotsapas, and Malecha, *op. cit.*, p.75.

56. Cheri Cohen, Aeration Industries International, item 16.7.28, *World Shrimp Farming*, July 1991, p. 20.

57. Some reports suggest that the ponds are closer to 1.0 hectares.

58. Sandifer, Cotsapas, and Malecha, *op. cit.*, p.75.

59. Hernesto Guerra, Manager, Crustaceos del Pacífico, personal communications, April 30, 1992.

60. Sandifer, Cotsapas, and Malecha, *op. cit.*, p.75.

61. Ramos, *op. cit.*

62. E.R. MacMichael, S.R. Malecha, T. Desmond, P. Sandifer, L. Cotsapas, "Innovative Commercial Development of Freshwater Prawns, *Macrobrachium rosenbergii* in El Salvador," paper delivered at Aquaculture '92, Orlando, Florida, May 24, 1992. The paper was presented by Spencer Malecha.

63. MacMichael, "Innovative," *op. cit.*

64. Ramos, *op. cit.*

65. Ministerio de Agricultura y Ganaderia, *op. cit.*, pp. 13-14 and Ramos, *op. cit.*

66. Sandifer, Cotsapas, and Malecha, *op. cit.*, p.74. Additional details are available in Ministerio de Agricultura y Ganaderia, *op. cit.*, pp. 14-17.

SECTION VIII (Harvests)

67. Linos Cotsapas, Research Planning Institute, Colombia, S.C. personal communications, July 15, 1989 and William More, Grenada Mariculture, *Aquaculture Digest*, September 1988. The Food and Agriculture Organization of the United Nations (FAO) shows much higher harvests for Salvadoran shrimp culture. FAO, "Aquaculture Production 1986-89," *op. cit.* The authors have been unable to confirm FAO data.

68. Michener, personal communications, *op. cit.*, August 27, 1990.

69. For an optimistic assessment of the current economic situation see Juan-Ramón, *op. cit.*, pp. 8-9.

70. Michener, personal communications, *op. cit.*, August 27, 1990.

71. Ramos, *op. cit.*

72. Maugle, item 13.3.33, *op. cit.*

SECTION IX (Yields and Production Costs)

73. Sandifer, Cotsapas, and Malecha, *op. cit.*, p.75 and Linos Cotsapas, "Economic Feasibility of Shrimp and Prawn Culture in El Salvador," paper delivered at Aquaculture '92, Orlando, Florida, May 24, 1992. FUSADES reports interest rates of 16 percent for working capital and 15.5 percent for fixed investment. Ramos, *op. cit.*

74. Sandifer, Cotsapas, and Malecha, *op. cit.*, p.74. For planning purposes, however, FUSADES has been using a "discounted" annual rate of 2.4 t per hectare. MacMichael, "Innovative," *op. cit.*

75. MacMichael, "Innovative," *op. cit.*

SECTION X (Processing Industry)

76. El Salvador's 1990 shrimp catch of 2,400 t could be processed in only about 70 days, given the 35 t capacity

of the processing industry.

77. Ministerio de Agricultura y Ganaderia, *op. cit.*, p. 18.

78. Sandifer, Cotsapas, and Malecha, *op. cit.*, p.71.

SECTION XI (Feed)

79. Cheney, *op. cit.*, p. 25.

80. Michener, personal communications, *op. cit.*, April 20, 1992.

81. Sandifer, Cotsapas, and Malecha, *op. cit.*, p.71.

82. Cotsapas, "Economic Feasibility," *op. cit.*

83. Ministerio de Agricultura y Ganaderia, *op. cit.*, p. 20.

84. Cotsapas, "Resources and Infrastructure," *op. cit.*

SECTION XII (Exports)

85. FAO, Fishery Country Profile, January 1986.

86. US export data cannot be used to precisely track industry developments. There is a sizable trade in smuggled shrimp in Central America. Growers in El Salvador, Honduras, and Guatemala sometimes ship seafood illicitly through El Salvador to avoid currency controls and fares. The extent and direction of the trade varies from year to year depending on tax and currency exchange regulations.

87. RDA sites the low tail to head conversion rate and the difficulties in marketing freshwater shrimp. Cheney, *op. cit.*, p. 8, 37.

88. Sandifer, Cotsapas, and Malecha, *op. cit.*, p. 72.

89. Spencer Malecha, Hawaii Aquaculture, "Export Market Development Efforts for El Salvador Aquaculture Products," paper delivered at Aquaculture '92, Orlando, Florida, May 24, 1992. For additional marketing details see H.R.A. Mejia, "Estudio de mercado y de promoción de langostinos de agua dulce (*Macrobrachium rosenbergii*, correspondiente a El Salvador," OLDEPESCA, 1991. 147 p.

SECTION XIII (Postlarval Supply)

90. Cheney, *op. cit.*, p. 24.

91. Ramos, *op. cit.*

92. Sandifer, "Commercial Marine Shrimp Culture," *op. cit.* For details on the Honduran shrimp culture industry see Dennis Weidner, "Honduran Shrimp Culture," *op. cit.*

93. Z. Horna, 1987, as cited by Cheney, *op. cit.*, p. 24.

94. Ministerio de Agricultura y Ganaderia, *op. cit.*, p. 20.

95. Sandifer, "Commercial Marine Shrimp Culture," *op. cit.*

96. Ramos, *op. cit.*

97. The group adds that the sites they have seen in El Salvador are among the best they have seen anywhere. Sandifer, Cotsapas, and Malecha, *op. cit.*, p.72.

98. Ernesto Daglio, General Manager, Oceanica, personal communications, April 30, 1992.

99. Sandifer, Cotsapas, and Malecha, *op. cit.*, p.75.

100. Sandifer, Cotsapas, and Malecha, *op. cit.*, p.74.

101. Rhina Guadalupe Serrano, "Freshwater Prawn Farming," *La Prensa Grafica*, August 22, 1983, p. 3.

102. At Izalco seawater had to be trucked in. Cheney, *op. cit.*, p. 24.

103. Ministerio de Agricultura y Ganaderia, *op. cit.*, p. 5, 7.

104. MacMichael, "Innovative," *op. cit.*

SECTION XIV (Government Role)

105. Ministerio de Agricultura y Ganaderia, *op. cit.*

106. Juan-Ramón, *op. cit.*, pp. 8-9.

107. Ministerio de Agricultura y Ganaderia, Centro de Desarrollo Pesquero, "El Cultivo de Camarón en El Salvador," presented at the Simposio Centroamericano sobre Camarón Cultivado, April 1991.

108. U.S. Embassy, San Salvador, May 19, 1987.

109. Martinez, *op. cit.*

110. Martinez, *op. cit.*

111. Juan-Ramón, *op. cit.*, pp. 8-9.

112. See, for example, Tom Gibb, "Salvadoran Wealthy Win Land Dispute," *Washington Post*, May 29, 1992, p. A28.

SECTION XV (Legal Framework)

113. "Reglamento para el establecimento de salineras y explotaciones con fines de acuicultura marina en los bosques salados," Decreto no,. 14, *Diario Oficial*, no. 56, tomo 291.

114. "La Ley General y Reglamento de las Actividades Pesquera," *Diario Oficial*, no. 169, tomo 272, September 14, 1991.

115. Ministerio de Agricultura y Ganaderia, *op. cit.*, p. 9-10.

SECTION XVI (Credit)

116. Gibb, *op. cit.*

117. Michener, personal communications, August 27, 1990.

118. *World Shrimp Farming*, May 1990 and Martinez, *op. cit.*.

119. More complete details on DIVAGRO assistance and the FIDEX credit program are available in Sandifer, Cotsapas, and Malecha, *op. cit.*, pp. 72-73 or from FUSADES (appendix A).

120. Michener, personal communications, August 27, 1990.

SECTION XVII (Technical Capability)

121. See Sanchez, *op. cit.* and Ulloa, *op. cit.*

122. R. Salgado, *Resultados del cultivo de Macrobrachium rosenbergii en estanques con diferentes densidades de siembra*, (CENDEPESCA-MAG: San Salvador, 1986).

123. CENDEPESCA eventually hopes to operate a total of 12 ha of trial ponds at El Zope for shrimp culture. Ministerio de Agricultura y Ganaderia, *op. cit.*, p. 7.

124. Ministerio de Agricultura y Ganaderia, *op. cit.*, p. 19.

125. Spencer Malecha, "The El Salvador Aquaculture Technical Assistance Program," paper delivered at Aquaculture '92, Orlando, Florida, May 24, 1992.

126. Ramos, *op. cit.*

127. Ministerio de Agricultura y Ganaderia, *op. cit.*, p. 7.

SECTION XVIII (Foreign Assistance)

128. *World Shrimp Farming*, May 1990. Taiwan specialists have assisted with the freshwater shrimp hatchery at the station. Ministerio de Agricultura y Ganaderia, *op. cit.*, p. 5.

129. Julio César Aizprua, "Paises centroamericanos valorizan sector pesquero," *La Prensa*, September 12, 1991 and OLDEPESCA, "Programa Regional de Apoyo al Desarrollo de la Pesca en el Istmo Centroamericano: Plan de trabajo, Primer Año de Operaciones," July 9, 1991.

APPENDICES

Appendix A. --El Salvador. Shrimp culture addresses.

El Salvador country code: 503

Government Agency

Centro de Desarrollo Pesquero (CENDEPESCA)
Ministerio de Agricultura y Ganaderia
Final la Avenida Norte
Santa Tecla, Departamento La Libertad
EL SALVADOR
Tel: 280-034, 280-074

Agriculture Diversification Program (DIVAGRO)
Address unavailable

Expoprt Investment Fund (FIDEX)
Address unavailable

Development Foundation

Salvadoran Foundation for Economic and Social Development (FUSADES): El Salvador Headquarters
Edificio FUSADES
Boulevard Santa Elena, Urbanización
Santa Elena, Antiguo Cuscatlán
La Libertad, El Salvador
Tel: 98-0385-89
FAX: 23-4723

FUSADES: Miami office
Inter-American Center
396 Alhambra Circle, Suite 602
Coral Gables, FL 33134
Tel: (305) 529-2233
FAX: (305) 529-9449

Industry Association

Asociacion de Acuacultores Salvadoreños (ACUASAL)
Apt. Postal 3332
San Salvador
El Salvador
Tel: 25-5744
FAX: 266-579

Farms

Agromarina
Address unavilable
Tel: 713-041

Agropecuario las Delicias del Mar
Address unavailable

Crustaceos del Pacifico
Bulevar de Hipodromo 405
Colonia de San Benito
San Salvador, EL SALVADOR
Tel: 239-033

Consultants

Aquatic Resources International
P.O. Box 16280
Colombia, S.C. 29412
Tel: (803) 795-0814

Hawaii Aquaculture: Hawaii Headquarters
1103 9th Ave., Suite 206
Honolulu, HI 96816

Hawaii Aquaculture: El Salvador Office
Calle Victor Mejia Lara #14-134
y Avenida Masferrer Sur
San Salvador, El Salvador
Tel/FAX: 235-711

RDA International
801 Morey Drive
Placerville, CA 95667
Tel: (916) 622-8800
FAX: (916) 626-7391

Research Planning, Inc. (RPI)
1200 Park St.
Colombia, S.C. 29201

Hatchery

Oceanica
47 Av. de Norte
Metro 2000
Locales 11-12 D
San Salvador, EL SALVADOR
Tel: 790-861
FAX: 791-018

Appendix B1.--El Salvador. Cultured shrimp harvests, 1986-91.

Year	Harvest		Total
	Freshwater	Marine	
	Metric tons		
1986	NA	NA	40E
1987	NA	NA	45E
1988	NA	41	45E
1989	3	57	60
1990	3	87	90
1991	10	46	56E
1992	NA	NA	150P

E - Estimated
NA - Not Available
P - Projected
Sources: William R. More, Grenada Mariculture Technologies, World Shrimp Farming, September 1988; Linos Cotsapas, Research Planning Institute, personal communications, July 15, 1989; Bruce Michener, U.S. AID Mission, San Salvador, personal communication, August 27, 1990; Sr. Ovando, Agromarina, personal communications, April 30, 1992; Hernesto Guerra, Crustaceos del Pacifico, personal communications, April 30, 1992; and Jorge Alberto Ramos, Aquaculture Manager, FUSADES, personal communications, June 18, 1992.

Appendix B2.--El Salvador. Total marine shrimp production, wild-caught and cultured, 1986-91.

Year	Harvest		Total	Proportion cultured
	Capture	Culture		
		Metric tons		Percent
1986	3,392	NA	3,392	NA
1987	2,871	NA	2,871	NA
1988	3,218	41	3,259	1
1989	3,585	57	3,642	2
1990	2,400E	87	2,487E	3
1991	3,000E	56	3,056E	2
1992	NA	150P	NA	NA

E - Estimated
NA - Not available
P - Projected
Sources: FAO Yearbook of Fishery Statistics, 1989 (1986-89-captured). William R. More, Grenada Mariculture Technologies, World Shrimp Farming, September 1988 (1988-cultured). Linos Cotsapas, Research Planning Institute, personal communications, July 15, 1989 (1989). Bruce Michener, U.S. AID Mission, San Salvador, personal communication, August 27, 1990 (1990-cultured). Sr. Ovando, Agromarina, personal communications, April 30, 1992 and Hernesto Guerra, Crustaceos del Pacifico, personal communications, April 30, 1992 (1991-cultured).

Appendix C1.--El Salvador. Active shrimp farms, 1989.

Farms	Pond Area	Harvest
	Hectares	Metric tons
Marine		
Agromarina de El Salvador	33	21.5
Crustaceos del Pacifico	10	6.4
Monteverde	52	18.0
Rey del Golfo	13	8.5
Subtotal, marine	108	54.4
Freshwater		
Mariscos Copricornios	2	1.9
Sinquil#	2	1.5P
Subtotal, freshwater	4	3.4P
Total	112	57.8

- Farm opened in September, 1989
NA - Not Available
P - Projected
Source: Linos Cotsapas, Research Planning Institute, personal communication, 1989.

Appendix C2.--El Salvador. Active marine shrimp farms, 1991.

Farm	Pond Area	Harvest	Annual yield
	Hectares	Metric tons	Tons/Hectare
Agromarina de El Salvador	27	35	1.3
Crustaceos del Pacifico	10	11	1.1
Total	37	46	1.2

Sources: Hernesto Guerra, Crustaceos del Pacifico, personal communications, April 30, 1992 and Sr. Ovando, Agromarina, personal communications, April 30, 1992.

Appendix C3.--El Salvador. Marine shrimp farms, 1992.

Farm	Pond area	Status
Agromarina	27	Active
Agropecuaria Las Delicias	60	Under construction
Crustaceos del Pacifico	10	Active
Monteverde	52	Closed
Rey del Golfo	13	Closed
Total	162	NA

Sources: Hernesto Guerra, Crustaceos del Pacifico, personal communications, April 30, 1992. Sr. Ovando, Agromarina, personal communications, April 30, 1992. Bruce Michener, U.S. AID Mission, San Salvador, personal communication, April 20, 1992. Elizabeth MacMichael, Hawaii Aquaculture, personal communications, April 30, 1992.

Appendix C4.--El Salvador. Shrimp farms, 1992

Species/project	Pond Area	System	Location
	Hectares		
Marine farms			
Monte Verde	57.0	Semi-intensive	
A. las Delicias	44.0	Intensive	
Agromarina	30.5	Semi-intensive	Los Cobanos
Rey del Golfo	13.0	Semi-intensive	
Crustaceos	10.0	Semi-int./intensive	Los Cobanos
(La) Trinidad	5.0	Extensive	
(El) Zope	3.9	Intensive	
(El) Botoncillo	3.0	Semi-intensive	
Total, marine	166.4		
Freshwater farms			
Palo Combo	5.1	Semi-intensive	
Singuil	3.5	Semi-intensive	
San Francisco Guajoyo	3.4	NA	
Zontemar	2.0	NA	
Others*	NA	NA	
	14.0**		
Total	180.4		

* Includes about 5 small scale growers.
** Does not include the area of several small farms.
Source: Paul Sandifer, Linos Cotsapas, and Spencer Malecha, "Aquaculture in El Salvador: Primed for Expansion," Aquaculture Magazine, May/June, 1992, p. 74.

Appendix C5.--El Salvador. Estimated marin and freshwater shrimp pond area, 1987-93

Year	Constructed			Active
	Freshwater	Marine	Total	
			Hectares	
1987	2	50	52	NA
1988	2	100	102	NA
1989	4	160	164	110
1990	NA	NA	170	NA
1991	15	NA	175	40
1992	20	162	182	120
1993	25P	375P	400P	300P

P - Projected
Note: Rough approximations of pond area trends based on scattered available reports.
Source: Apendices C1-4 and scattered reports from a variety of sources.

Appendix D.--El Salvador. Shrimp hatcheries, 1992

Hatchery	Location	Species	Monthly capacity	Status
			Million pl	
Acuisal	San Diego	Macrobrachium	0.5	Operating (1991)
Acuasal	(La) Zunganera	Macrobrachium	0.2	Not operating
Oceania	NA	Penaeids	5.0-6.0	Completion: late 1992
Crustaceos del Pacifico	(El) Tequillo	Penaeids	0.5	Not operating
Estacion de Maricultura	(El) Zope*	Penaeids/Macro.	NA	Unknown

* Government hatchery operated by CENDEPESCA.
Source: Paul Sandifer, "Commercial Marine Shrimp Culture in El Salvador: Case Studies," paper delivered at Aquaculture '92, Orlando, Florida, May 24, 1992 and Ministerio de Agricultura y Ganaderia, Centro de Desarrollo Pesquero. "El Cultivo de Camarón en El Salvador," presented at the Simposio Centroamericano sobre Camarón Cultivado, April 1991.

Appendix E1.--El Salvador. Potential sites and area for marine shrimp ponds.

Location	Estimated Area	Characteristics
	Hectares	
Eastern Zone		
Barra de Santiago	200	Marshland
Metalio	300	Pasture and brush
Acajutla	700	Some sites near mangroves
La Libertad	250	
Subtotal	1,550	
Central Zone		
Rio Jiboa	-	Competition with cotton farmers
Rio Lempa	200	El Naranjo salt pans
Jiquilisco	8,000	
El Triunfo	2,050	
Bocana La Chepona	300	
Subtotal	10,550	
Western Zone		
El Tamarindo	260	Salt pans and marsh
La Union and Coascoran	1,200	
Subtotal	1,460	
Total	13,460	

Source: Daniel Cheney, et. al., El Salvador Aquaculture Feasibility Study: Informational Summary, RDA International, 1988, p. 36.

Appendix E2.--El Salvador. Potential sites for marine shrimp farms

Type	Area
	Hectares
Salt pans	2,310
Adjacent to salt pans	3,700
Other sites	7,450

Source: Daniel Cheney, et. al., El Salvador Aquaculture Feasibility Study: Informational Summary, RDA International, 1988, p. 36.

Appendix E3.--El Salvador. Potential sites and area for marine shrimp ponds.

Zone	Location	Estimated Area
		Hectares
Western	Guatemalan border to La Libertad	2,700
Central	Bahia de Jiquilisco	3,600
Eastern	Golfo de Fonseca	1,800
Total		8,100

Source: Paul Sandifer, Linos Cotsapas, and Spencer Malecha, "Aquaculture in El Salvador: Primed for Expansion," Aquaculture Magazine, May/June, 1992, p. 72.

Appendix F.--El Salvador. Principal shrimp packers, 1988

Port/Company	Capacity
	Tons per day
Acajutla	
Pescera del Inustrial (Pices)	SC
La Libertad	
Cooperativa La Libertad	SC
Pezquera del Pacifico	SC
La Union	
Multipesca	NP
Veralmar	4.5
Puerto El Triunfo	
Atarraya	13.6
Pezca	9.1

NP - Not processing shrimp in 1988, but has done so in the past and could resume such operations.
SC - Small capacities, but exact details unavailable.
Note: These two packing plants alone have the capacity to process to process El Salvador's entire 1990 shrimp catch (2,400 t) in less than 100 days.
Source: Cheney, Daniel, P. de Rito, G. Bonacker, J. Richardson, K. Sackheim, D. Sweat, and D. Wilson. El Salvador Aquaculture Feasibility Study, RDA International/FUSADES, 1988, p. 26.

Appendix G1.--El Salvador. Shrimp exports by country, 1980-91

Year	Country			Total
	U.S.	E.C	Japan	
	1,000 Metric tons*			
1980	2.8	-	-	2.8
1981	3.0	Negl.	-	3.0
1982	3.3	-	-	3.3
1983	2.1	-	-	2.1
1984	3.9	-	-	3.9
1985	2.8	-	-	2.8
1986	3.5	-	-	3.5
1987	3.3	-	-	3.3
1988	3.7	-	-	3.7
1989	2.8	-	-	2.8
1990	2.4	-	-	2.4
1991	2.1	NA	-	NA

NA - Not available
* Product weight
Sources: U.S. Bureau of the Census, EC NIMEXE, and the Japan Tariff Association, and the Canadian Department of Fisheries and Oceans.

Appendix G2.--United States. Shrimp imports from El Salvador, 1986-91.

Year	Quantity
	Metric Tons
1985	2,800
1986	3,500
1987	3,700
1988	3,700
1989	2,800
1990	2,400
1991	2,100

Source: US Department of Commerce.

3.4

GUATEMALA

Guatemala has emerged as one of the leading Central American producers of cultured shrimp behind Honduras. While potential pond area may be more limited than in other Central American countries, adequate farm sites appear available for a small, but profitable industry. Current growers are reporting increasingly successful operations. The Guatemalan shrimp fishery has traditionally been one of the smallest in Central America, making only a small contribution to the national economy. Increasing cultured harvests, however, are substantially expanding the country's shrimp harvest and generating sharply higher export earnings. Shrimp culture is a newly developing industry in Guatemala, but harvests increased abruptly in 1990 to nearly 1,800 t and may approach 2,400 tons in 1991. Several growers are reporting substantial improvements in yields and harvests. Most observers believe further increases are likely in 1992 when several pond expansion programs become fully operational. Harvests should expand steadily throughout the 1990s. Growers should be able to exceed harvests of 7,000 t by the year 2000 and some observers believe even larger harvests are possible, especially if current trials with intensive systems prove profitable.

CONTENTS

I. CAPTURE FISHERY

Guatemala conducts the smallest shrimp fishery in Central America, with the exception of Belize. The Guatemalan shrimp fishery consists of both a commercial trawl fishery conducted offshore all along the coast and artisanal operations in the estuaries.

Commercial fishery: The shrimp trawl fishery is Guatemala's only important commercial fishery.[1] Guatemalan observers report, however, that the fisheries for shark and snapper/grouper have grown in recent years.[2] The shrimp trawl fishery was initiated in the late 1950s by a company which deployed two vessels. The company expanded to seven vessels in 1962. Other companies entered the fishery and the fleet increased to about 30 trawlers during the 1960s. The shrimp fleet consisted of about 35 trawlers in the early 1980s. The Government reportedly approved the authorization of 14 new licenses in 1985.[3] Shrimp are fished along the entire Pacific coast with the exception of a few rocky areas. The narrow Guatemalan shelf limits the resource. The fishermen generally operate in water up to 70 meters (m), actual operations depending on the target species. (See: "III. Species.") The fishermen occasionally fish as deep as 120 m, but have not found commercially exploitable stocks in deeper waters. The fishery was complicated by inadequate facilities at the principal port, Puerto San Jose and Champerico, but the opening of Puerto del Pacifico near San Jose has eased the problems formerly experienced with landing the catch.[4] Almost all of the catch is taken along the Pacific coast, but a few trawlers have occasionally been deployed off the small Caribbean coast.

Artisanal fishery: Artisanal fishermen operate in the estuaries, taking juveniles with cast nets and gillnets.

One observer estimates the maximum sustainable yield (MSY) of the Guatemalan shrimp fishery at about 1,700 metric tons (t), which would support about 45 trawlers. A record catch of 3,100 t was reported in 1966. Catches during the 1980s have varied from 1,100 t (1987) to 2,800 t (1981) (appendix B1 and figure 1).[5]

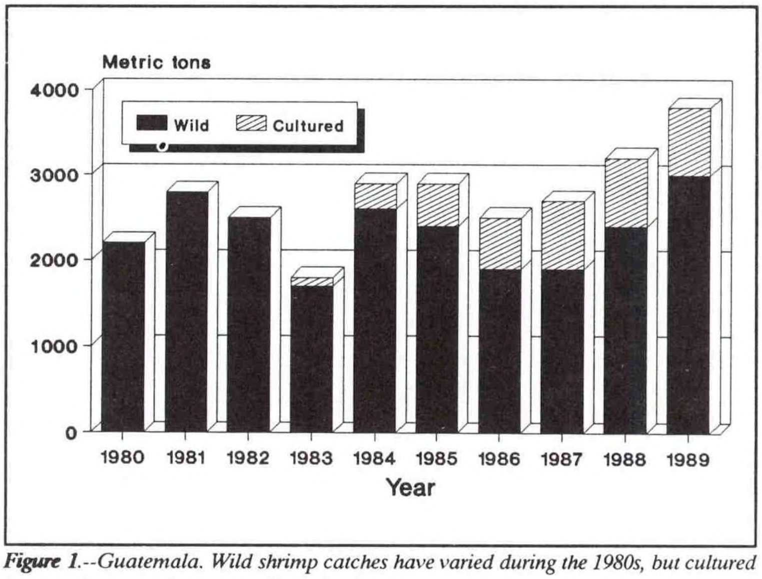

Figure 1.--Guatemala. Wild shrimp catches have varied during the 1980s, but cultured harvests have made an overall production increase possible.

The Guatemalan Government enforces two seasonal closures.[6]

Offshore closure: All shrimp fishing is prohibited from April 15 to May 30.[7]

Inshore closure: Postlarvae collection in the estuaries are prohibited from September 1 to October 15.[8]

II. SPECIES

Guatemalan fishermen take a variety of *Penaeid* and non-*Penaeid* species. The *Penaeid* species generally account for about half the catch (appendix B2). The most important *Penaeid* species are white (*Penaeus vannamei* and *P. stylirostris*) and yellowleg/brown shrimp (*P. californiensis*). The *P. vannamei* catches are best from September to November and are taken in water from about 15-40 meters. *P. stylirostris* catches are best from November to January, primarily at depths of about 10-15 meters. *P. californiensis* is mostly taken from November to January at depths of 30-40 meters. Smaller amounts of crystal/red (P. brevirostris) shrimp are also taken. The fishing is best from July to September at depths beyond 50 meters. The other half of the catch is a variety of smaller non-*Penaeid* species, primarily seabobs (*Xiphopenaeus* sp.) and chacalín/tigre (*Trachypenaeus faoe*). Much of this smaller shrimp is taken from April to October at depths ranging from about 10-40 meters.

Guatemalan growers use only a small number of species. Marine growers use the two Pacific white shrimp, primarily *P. vannamei* (90 percent), but also lesser amounts of *P. stylirostris* (10 percent). Some investors have expressed an interest in culturing *P. schmitti*, an Atlantic white shrimp, along the Caribbean coast.[9] Freshwater growers use *Macrobrachium rosenbergii*.

III. GROWING CONDITIONS

Guatemala is the most northerly and most populous of the Central American countries. Climatic conditions are favorable for culturing shrimp, but the potential for commercial development

Map 1.--Map of Guatemala.

exists primarily along the Pacific coast.

Pacific coast: Guatemala has a Pacific coast of about 230 kilometers. Mountains follow the contour of the Pacific coast. The coastal plain is a narrow belt of 50 kilometers (km) or less between the mountains and the Pacific Ocean. The mountains are drained by short rivers. The narrow coastal plain has few of the bays, estuaries, and salt flats used by growers in other Central American countries.[10] While there is a relatively small area of suitable sites, potential growers have access to wild postlarvae (pl) which can be collected for seedstock. The country's population is centered in the coastal highlands which means that the infrastructure along the adjacent Pacific coastal plain is much more developed, facilitatingconstruction projects. Guatemalan conditions are somewhat comparable to those in the neighboring Mexican state of Chiapas.[11]

Caribbean coast: Guatemala has a very limited Caribbean coast, only a narrow access to the Caribbean wedged between Belize and Honduras and extending only about 80 kilometers. Much of the small Caribbean coastal area is not suitable for pond construction. The soils are mostly sandy. In addition poor infrastructure and unsuitable indigenous species would complicate pond construction and operation.[12]

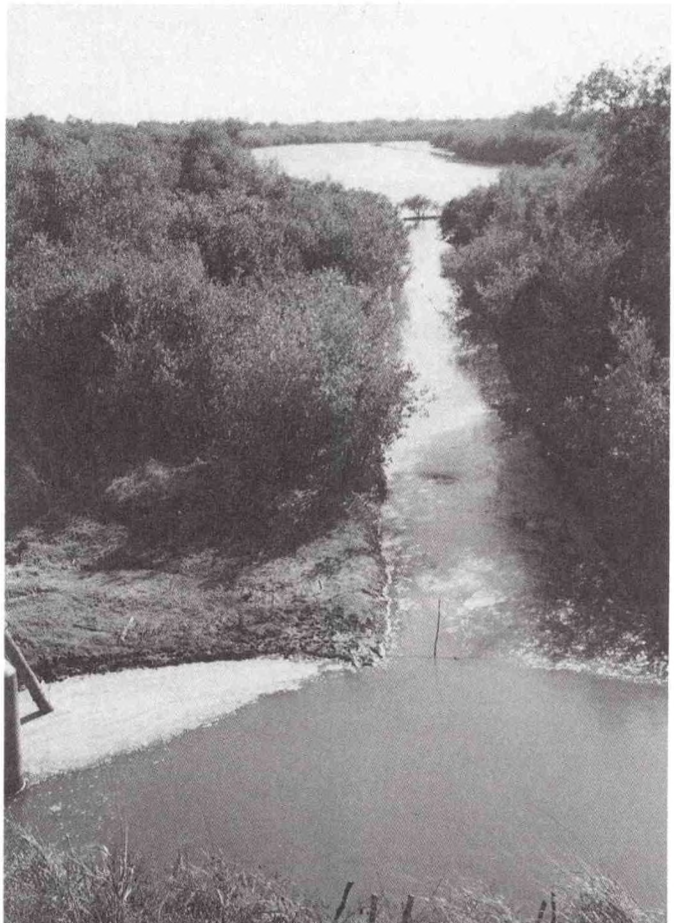

Photo 1.--*Guatemala. Water intake from a Pacific coastal estuary with mangrove forestry. © James Wyban, Oceanic Institute.*

Guatemala experiences two distinct seasons, a rainy (May-October) and dry (November-May) season. Rainfall is heaviest in central Guatemala along the slopes exposed to the Caribbean winds and in the south along the slopes exposed to the Pacific winds. Annual rainfall in these areas ranges from 180 centimeters (cm) to more than 500 centimeters. During the driest months (usually January and February) rainfall averages less than 5 cm per year, especially along the Pacific coast. As a result, this dry period can be a problem for growers who are currently all located along the Pacific coast. Along the Caribbean, rainfall is usually plentiful throughout the year.

IV. POND AREA

Guatemala has a relatively small potential area with suitable conditions for shrimp culture. A 1987 FAO study estimated the potential area at about 4,000 hectares.[13] Another observer believes that the potential area could be as high as 8,000 hectares.[14] While the area is only a small fraction of that available to growers in the larger countries (Brazil, Colombia, Ecuador, and Mexico), the potential area is sufficient to support a modest shrimp culture industry which could have a substantial economic impact on the small Guatemalan economy.

The accuracy of the estimates assessing the potential area suitable for pond construction is unclear. Some growers are already experiencing problems finding additional sites with acceptable conditions. One observer believes that a shortage of sites is currently the industry's principal problem.[15] Another report suggests that land costs are relatively high in Guatemala.[16] An industry group confirms the relatively high land costs.[17] Clearly many of the best sites have been developed and land prices are

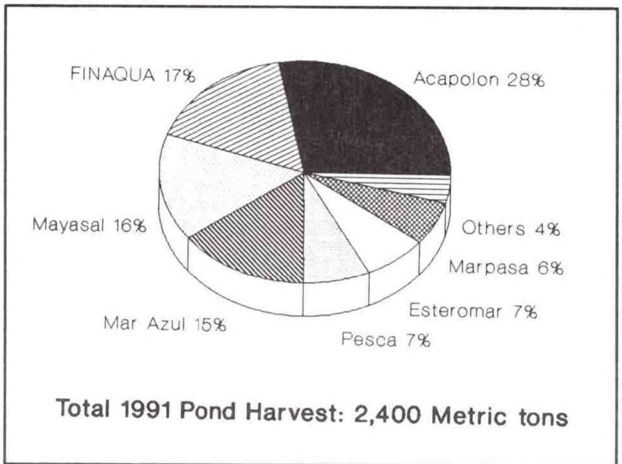

***Figure** 2.--Guatemala. A small number of companies currently dominate the industry.*

increasing for the remaining sites. One observer estimated costal land prices during 1991 varying from $1,500-3,000 per hectare.[18] Pollution problems are reported at some potential sites. Otherwise suitable sites on former cotton plantations near the Mexican border have chemical residues in the soil which can cause mortalities in shrimp growout operations.[19]

Shrimp farms have been built at sites located all along Guatemala's Pacific coast (appendix C2). The Government reports that the area of constructed ponds totals 1,300-1,500 hectares.[20] Industry sources report somewhat lower estimates, 1,200-1,300 hectares (ha) (appendix C1-2 and figure 2).[21] One industry source suggests, however, that these estimates may be high and the actual pond area is only about 1,100 hectares (appendix C3).[22]

Guatemalan growers report relatively low pond utilization rates. Only about half of the available ponds (approximately 650 ha), were in production during 1990. Utilization probably increased to about 775 ha of ponds during 1991 (appendix C3).[23] The low utilization rate is due to the closure of some small farms and major construction/redesign projects at Acapolon and Fincas Aquaticas which are scheduled for completion during late 1991 or early 1992. The utilization rate should increase considerably in 1992 when those engineering changes are completed and the newly built and/or redesigned ponds stocked.[24]

Little information is available on future pond construction plans. Several growers are currently conducting important pond construction or redesign projects. (See: "VII. Farms".) Less information is available on future plans. Growers estimate that they could build about 1,200 ha of additional ponds at existing farm sites (appendix C2). Government 20 officials expect growers to increase pond area to about 2,000 ha by 1993.[25]

V. POSTLARVAL SEEDSTOCK

Growers currently use wild pl to stock their ponds and it is reportedly available in adequate quantities.[26] The availability of wild pl is a significant advantage that Guatemalan growers have over growers in several other countries which have had to initiate costly and often marginally successful hatchery programs.[27] There appears to be sufficient pl available in Guatemalan estuaries to supply the pond area of existing farms.[28] One observer estimates that up to 3,000 ha of ponds could be stocked with pl collected from the wild.[29] Postlarvae shortages could develop, once growers expand pond area beyond this level and increase stocking densities. Growers also face opposition by local fishing groups which have criticized the collection of pl in the estuaries.

A. Wild postlarvae

Wild pl appears to be currently available in adequate quantities. Pl prices are much lower than in many other countries.[30] The low prices confirm that pl are relatively easy to collect and fairly abundant.

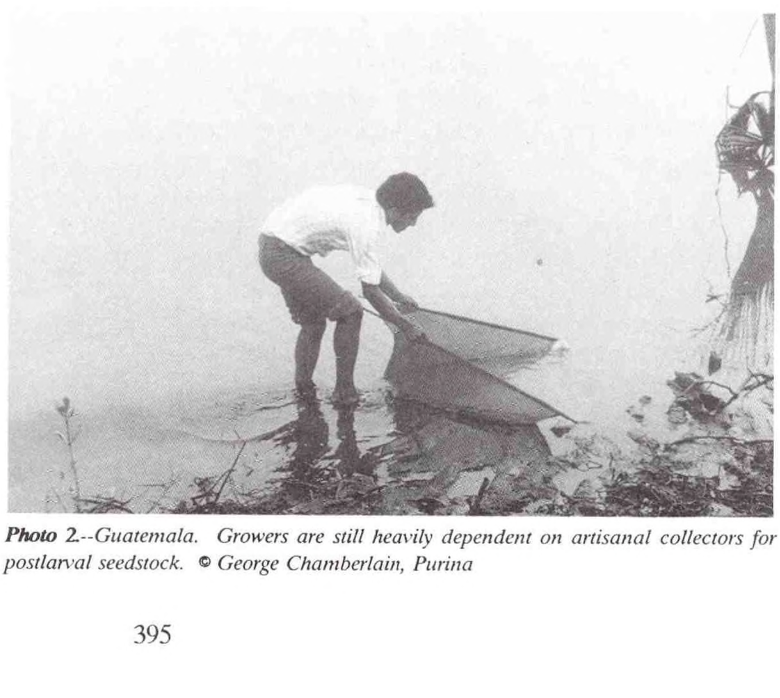

***Photo** 2.--Guatemala. Growers are still heavily dependent on artisanal collectors for postlarval seedstock. © George Chamberlain, Purina*

Some observers report that while pl has generally been available, the collection system poses a variety of difficulties for the industry.

Transportation: Growers currently encounter problems because the areas where pl can be collected are located at some distance from the farms.[31]

Supply fluctuations: Pl supplies fluctuate seasonally and may not always be available in adequate quantities when required. This has not yet been a problem in Guatemala as the small pond area and low stocking densities at extensive farms have limited pl requirements. As growers expand pond area and intensify operations, pl requirements are increasing. Some growers may have difficulty obtaining pl during these periods of seasonally low abundance.[32]

Government restrictions: The Government is concerned about the impact of pl collection on wild stocks of both shrimp and other species taken incidentally. The Government in 1989 implemented a 60-day seasonal closure which was reduced to 45 days in 1990 and 1991.[33] The fishermen, who object to wild pl collection, complain that the Government is not enforcing the seasonal closures.[34]

Legal difficulties: Dated laws regulating aquaculture also frequently cause problems for growers trying to transport collected postlarvae. Some growers are concerned, however, that the new law being considered by the Guatemalan Congress could complicate or even prohibit wild pl collection. (See: "XII. Government Role/Legal Framework.")

Confrontations: The opposition of fishermen (both artisanal and commercial) to pl collection has resulted in some potentially serious incidents. Local artisanal fishermen complain that the collection of pl is adversely affecting their catches because pl of many species die in the collection process, including the species which they target.

Collection process: Most growers purchase pl from artisanal fishermen,[35] but some also conduct their own collection operations. The collection process is time consuming and pl are often collected at some distance from the farms, complicating handling and transportation. The pl supply problem does not appear to be serious at this time and the developing 1991-92 El Niño suggests that the 1992 pl supply situation will be favorable. The fact that growers have not yet built hatcheries confirms the fact that they are currently able to obtain adequate postlarvae. The pond expansion programs at several farms and the spreading tendency to intensify operations suggest that pl demand will increase sharply in 1992 and 1993. Most growers would probably prefer to continue using wild pl, both because it makes costly hatchery investments unnecessary and because growers throughout Latin America have generally reported superior results with wild postlarvae. While growers will probably not exceed 3,000 ha of ponds until the mid-1990s, seasonal fluctuations could begin causing temporary shortages in the next few years, perhaps as early as 1993 or 1994.

B. Hatcheries

Guatemala has no active marine shrimp hatcheries and no projects are known to have reached the construction phase.[36] As a result, growers have few options and remain dependant on wild collected pl to stock their ponds. A few groups have attempted to build hatcheries, but the only operating facilities are small, primitive facilities for freshwater shrimp (appendix D). Some marine shrimp growers are reportedly giving increased consideration to possible hatchery projects.[37] One leading grower reports that his company has prepared a feasibility study and design specifications for a hatchery. As long as he can obtain adequate quantities of wild pl, he does not plan to proceed with the hatchery project.[38] Another

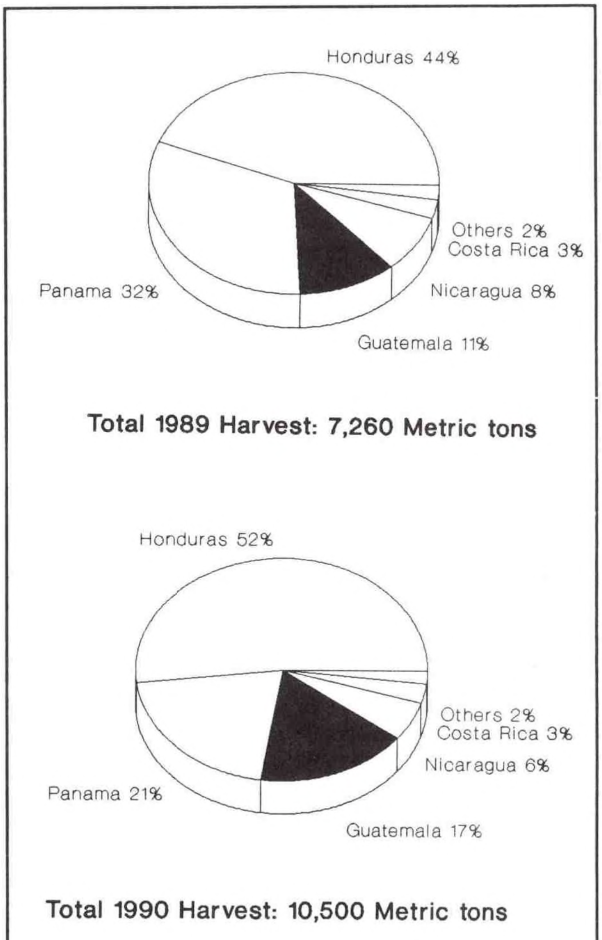

Figure 3.--Central America. Guatemalan growers are playing an increasingly important role in the region's cultured shrimp industry.

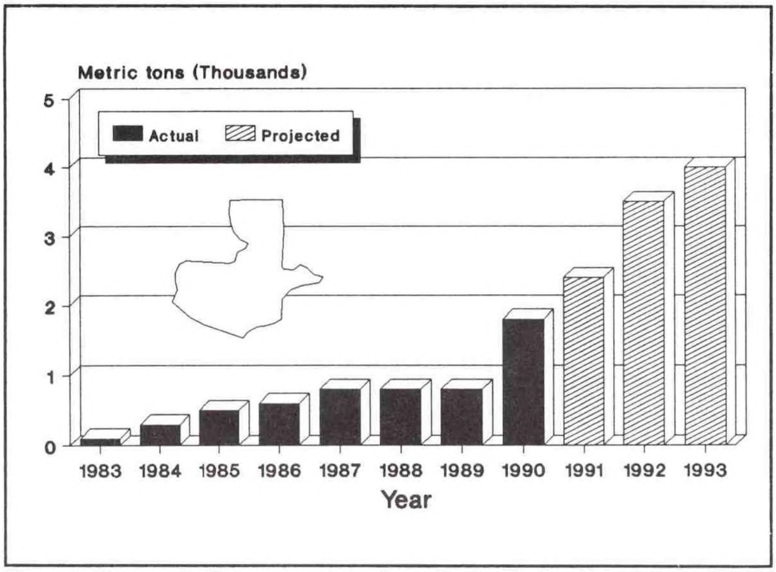

Figure 4.--Guatemala. Growers are projecting major harvest increases during the 1990s.

report suggests, however, that one grower may begin construction of a hatchery in 1992.[39]

C. Imports

Government officials report they have no knowledge of pl imports.[40] One industry source also reports that Guatemalan farms are not importing postlarvae.[41] Another observer suggests that a few growers have reportedly imported small amounts of pl, but no details are available.

VI. HARVESTS

Growers play a key role in the Guatemalan shrimp industry. Because of the relatively small capture fishery, growers emerged as a major sector at a relatively early stage in the industry's development. By 1985, growers were producing about 25 percent of the overall shrimp harvest and supplying important quantities of the export-grade shrimp. (See: "XI. Markets.") If current trends continue, growers should produce more than half of the country's shrimp production in 1991 (appendix B1). The only important producer of cultured shrimp with a higher proportion is Honduras (appendix B3A-B and figures 3 and 4).[42]

Guatemalan pond harvests are still small, but steadily increasing. The first attempts at shrimp culture in Guatemala proved largely unsuccessful. Few Guatemalans had any experience or advanced academic background with any form of aquaculture, let alone more technically sophisticated mariculture. Growers did not report their first commercial harvests until 1983. They slowly increased harvests through 1987 (appendix B1 and figure 4). Growers have reported that harvests stabilized at about 800 t from 1987-89.[43] No details are available as to why the harvest leveled off during this period, but it could reflect the lack of accurate statistics. One source reported a substantial harvest increase to 1,060 t in 1990 (appendix B1).[44] Unconfirmed reports from individual farms suggest that the actual 1990 harvest may have been somewhat higher, perhaps nearly 1,800 t (appendices C1). A Government source suggests an even higher 1990 harvest of as much as 1,700 tons.[45] Most observers report another major increase in 1991 based on optimistic reports from several growers. Industry sources project a 1991 harvest of nearly 2,400 tons (appendix B1 and C3 and figure 4).[46] In Central America, only Honduran growers harvest more shrimp (appendix B3).

Future harvests are difficult to assess. Most observers expect Guatemalan growers to report substantial harvest increases during the 1990s. Growers should be able to harvest 4,000 t by 1993. If pond expansion and technical improvements continue at current rates, Guatemalan growers should achieve quite substantial harvest increases. The industry has expanded to a point that considerable numbers of Guatemalans are gaining experience in operating fairly sophisticated semi-intensive systems. The absence of trained personnel during the early phases of several farms complicated initial operations. The expanding pool of trained personnel should facilitate future expansion. Current trends suggest that growers should be able to achieve a 7,000 t harvest by the year 2000. Other factors suggest that some caution should be used in assessing the Guatemalan situation. The small potential pond area and high land costs limit overall expansion. The more sophisticated facilities now being built require larger investments. Little information is available on production costs and profitability at the farms. Even so, some observers are optimistic about the future. If growers continue to improve yields at the existing semi-intensive farms and if the current trials with intensive systems prove profitable, Guatemalan growers may be able to expand harvests substantially

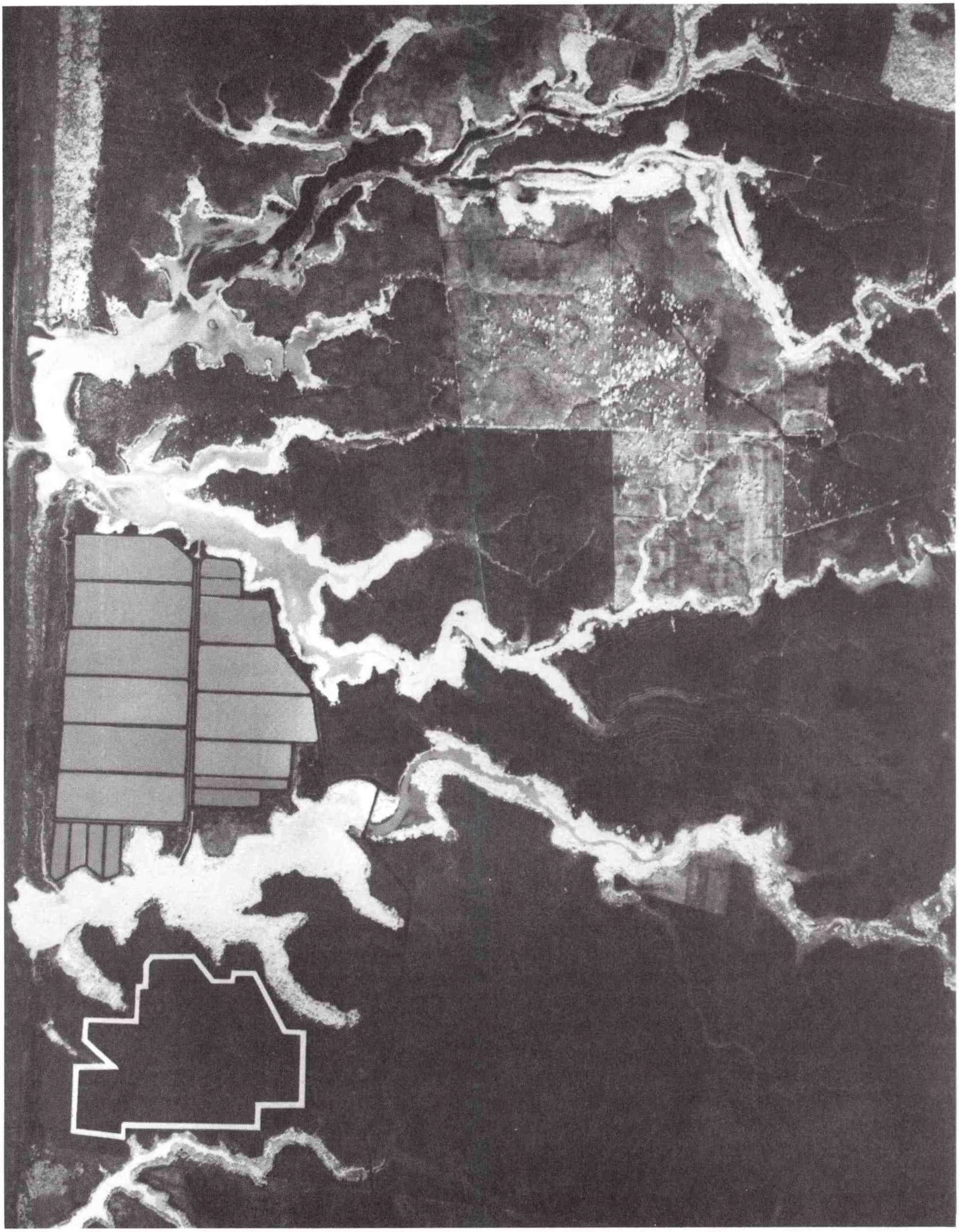

Photo 3.--*Guatemala. Aerial view of the important Acapolon farm at Champerico. The company is reporting very impressive yields. © Acapolon*

above the 7,000 t level.

Guatemalan growers, as in other Latin American countries, are harvesting primarily large and medium shrimp. The harvest is composed primarily of 31-35 (large), 36-40 (large-medium), and 41-50 (medium) count shrimp.[47] The growers are unable to profitably harvest the extra-large and jumbo-sized shrimp taken by the trawl fishermen.

VII. FARMS

Guatemalan growers culture mostly marine species. Currently about 20 growers are actively conducting growout operations (appendices A and C1-3). The industry formed a trade association, the Asociación de Criaderos de Camaron, in 1989. The Cámara de Industrias de Guatemala (Guatemalan Chamber of Commerce) has also been active. The Cámara's Gremial de Exportadores de Productos no Tradicionales has a Comisión de Recursos Hidrobiológicos which promotes the activities of all seafood producers.

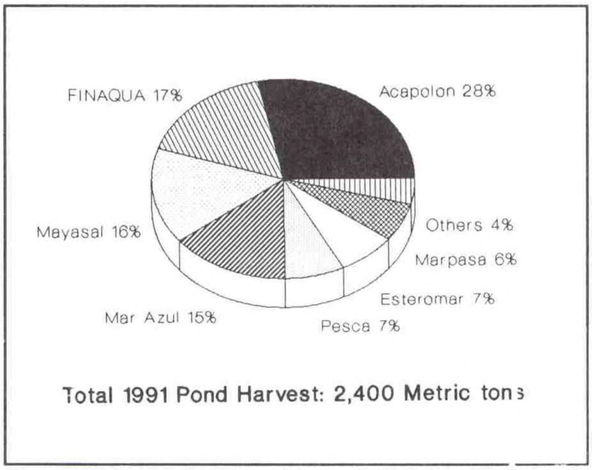

***Figure** 5.--Guatemala. Acapolon reported the largest harvest in 1991.*

A. Freshwater culture

The Guatemalan Government and private groups began experimental runs with freshwater shrimp in 1980. Only a few private investors have attempted to farm freshwater shrimp, primarily because of the limited export market. One observer suggests that the limited supply of seedstock has also been a major problem.[48] Most groups have encountered financial difficulties.[49] One report suggested that freshwater growers in 1988 operated about 25 ha of ponds and harvested about 12 t of shrimp.[50] One observer reports, however, that in 1991 there were no active freshwater farms.[51] Another report indicates, however, that two minor operations were underway during 1991, **San Agustín Ixtacapa** and the **Centro de Estudios del Mar y Acuacultura** (CEMA). The principal projects have included:

Aquafauna began operations in 1980 with a small hatchery at Amatitlan and growout ponds at Escuintla. Technical assistance was obtained from the Institute of Agricultural Science and Technology (ICTA) and the Taiwan Aid Mission.[52] The company eventually closed, but no details are available.

Centro de Estudios del Mar y Acuacultura (CEMA): CEMA operates a hatchery which sells pl to growers. Prices in early 1991 were relatively high, $23 per thousand postlarvae.[53] Such sales suggest that there are still some active freshwater culture operations, but the identity or scale of these operations is unknown.

Empresa Acuacultura de Guatemala (EAG): EAG initiated a project near Champerico to culture freshwater shrimp in 1980 which included a small hatchery.[54] Investments totaled $1 million. Two U.S. experts were hired for technical assistance. The farm closed, however, in 1982 after experiencing a variety of technical problems.

San Agustín Ixtacapa: This small farm located at Mazatenango reportedly operates a few ponds in 1991, but no harvest data is currently available.[55]

B. Marine culture

Guatemalan marine shrimp culture began in the 1970s when the first trial ponds were built. Early growers reported only erratic results, however, until the early 1980s.[56] Growers did not report successful commercial operations until 1983 when five farms were opened. The industry currently consists of more than 15 companies. The farms are scattered at various locations all along the Pacific coast, but about half are located along the western zone of the Pacific coast.[57] The greatest number of farms are located in the areas near Champerico (Retalhuleu) and Iztapa (Escuintla). Most have relatively small pond areas, but seven farms currently harvest over 100 t of shrimp annually (appendices C3 and figure 5). No farms are known to exist along the country's small Caribbean coast. Guatemalan investors own and operate the farms, but foreign interests participate in several companies.[58] Available details on individual farms are as follows:

Acapolon is one of the more important Guatemalan shrimp farms.[59] The farm is located at Champerico

Photo 4.--*Guatemala. Aerial view of a Guatemalan farm.* © *James Wyban, Oceanic Institute*

(Retalhuleu). The company was Guatemala's most important producer of cultured shrimp in 1991 (appendix C1-3). Acapolon initially operated an extensive system, but is currently intensifying operations. Company officials report that new, smaller ponds will enable it to employ higher-yielding, Taiwan-style methods.[60] Acapolon officials in 1990 reported yields of up to 3.8 t per hectare.[61] The company harvested 450 t of shrimp in 1990 from 91 ha of ponds (87 ha of growout pond and 4 ha of nursery ponds) (appendix C1-2). Acapolon completed an expansion program in mid-1991 and currently operates over 120 ha of ponds. About 96 ha (87 ha of growout ponds and 9 ha of nursery ponds) are operated on a semi-intensive system. An additional 26 ha are operated on an intensive system with full aeration. The company hopes to have an additional 25 ha of intensive ponds operational by mid-1992.[62] Recent harvests from the intensive ponds have averaged 5.5 t (liveweight) per hectare. The company projects a substantial harvest increase in 1991, which may total nearly 670 tons (appendix C3). The new ponds completed in 1991-92 should permit another major harvest increase in 1992. Acapolon plans to eventually build another 150 ha of ponds at a second site located across the estuary from the existing farm. The company is owned by a group of Guatemalan and U.S. investors.[63] It is the only farm in Guatemala and one of the few in Latin America to have a packing plant built at the farm itself, giving the company the ability to produce an extremely high grade product.[64]

Agro Marinas de Guatemala: Little information is available on this small farm located at Champerico (Retalhuleu). One unconfirmed report suggests that they have had disappointing results with their 80 ha of high-density ponds,[65] but no harvest data is available (appendices C1-3).

Aqua Industrias Mar Azul is located at Champerico (Retalhuleu). It operated about 100 ha of ponds in 1990, but has the area to more than double the existing pond area. Harvests totaled 200 t in 1990 (appendix C1), with annual yields of about 2 t per hectare. The company is reportedly using some Taiwan-style methods to increase yields. Mar Azul is rapidly becoming one of Guatemala's leading farms. One observer reports that the company is achieving a substantial harvest increase in 1991 and may reach 350 tons (appendix C3). The farm is wholly owned by a Guatemalan investor.

Aguas Marinas de Guatemala (AMG) is located at Tahuesco (Suchitepecue). It operated 80-100 ha of ponds in 1990, but has the land to more than double that area. No expansion programs, however, are currently envisioned. The company reported a 200 t harvest in 1990, which would mean annual yields in excess of 2 t per hectare. AMG has reportedly completed some experiments with intensive methods. It is fully Guatemalan owned.

Esteromar is a relatively small farm located at Iztapa (Escuintla). It operated 50 ha of ponds in 1991 and has plans to expand to 200 ha by 1993. The harvest was 164 t in 1990 which the company increased to 218 t in 1991. The 1991 yield was an impressive 4.4 t per hectare. The shrimp is marketed in France and the United States.[66]

Fincas Aquaticas (FINAQUA) is Guatemala's largest farm (appendix C1-3). Since it leased the former Granjas Marinas farm (August 1990), the company has redesigned and rebuilt 445 ha of the original 500 ha of ponds.[67] About 400 ha of ponds had been reactivated by October 1991 and the remaining 45 ha should be operational by November.[68] Company officials are planning a major expansion program and beginning in 1992 plan to expand pond area by 100-200 ha per year.[69] FINAQUA's has just begun to report harvests because only a few ponds were operational and stocked during 1991. The original Granjas Marinas ponds were designed for low-yielding, largely extensive methods. FINAQUA is operating the rebuilt ponds on a semi-intensive system.[70] FINAQUA is reporting very successful results with preliminary yields totaling 1.4 t per crop.[71] No harvest was reported in 1990, but a 400 t harvest is projected for 1991 (appendix C3). The acquisition and redesign project should enable FINAQUA to report a very substantial harvest increase in 1992. Some of the harvest is being exported heads-on to France. The company is fully Guatemalan owned, but is currently considering a partnership with a U.K. investment company.

Granjas Marinas was the country's first and largest shrimp farm, located at La Chorrera (Retalhuleu), near the Mexican border. The company was owned by Guillermo Aguirre. About 180 ha of ponds were built on the 3,500 ha property in 1979-81 as a joint project with Sea Farms in Honduras. The project involved a U.S. consulting company, Shrimp Culture, Inc. The company obtained seedstock by catching berried females near the mouth of the Acos River and producing pl in a hatchery operated by Sea Farms in Honduras. The practice was eventually discontinued because of a variety of problems associated with the collection process.[72] Additional ponds were built in 1984-85 bringing the total to 500 ha which were operated on an extensive system. The company reportedly experienced some success and in the mid-1980s planned a major expansion program.[73] Details on operations are unavailable, but Granjas Marinas has terminated operations.[74] FINAQUA

Photo 5.--*Guatemala. Aerial view of Mayasal shrimp farm.* © *Gabriel Biguria, Mayasal*

acquired a 20-year lease in 1990 to operate the facility.[75]

Maricultura del Pacifico (Marpasa) is located at Champerico (Retalhuleu). It operates about 75 ha of ponds and reportedly has considerable area for expansion. The company harvested 110 t of shrimp in 1990 and plans to harvest about 150 t in 1991 (appendix C1-3). Marpasa built a small hatchery in 1987[76], but it does not appear to be currently in operation. Marpasa is a joint venture between Guatemalan and United States (Continental Fisheries) interests. The company hopes to double pond area by 1992.

Mayasal is one of the larger Guatemalan shrimp farms. It was opened in 1983-84 and is located near Las Lisas (Santa Rosa). The first construction stage (68 ha of ponds) was completed in 1984. The second stage (138 ha) was completed in 1986. Total water surface was about 200 ha in 1990, 174 ha of growout ponds and 26 ha of nursery ponds and canals. The company recently completed an additional pond construction program. Mayasal reports that 222 ha of ponds had been built by 1991, including 20 ha of nursery ponds.[77] The new ponds were first stocked in July 1991.[78] The company harvested 350 metric tons in 1990 and plans to harvest about 370 t in 1991 (appendices C1,3). The first full-year operations from the new ponds should permit a substantial harvest increase in 1992. One observer reports that the company is one of Guatemala's more modern farms and 1990 yields totaled about 2 t per hectare. The company is considering a possible hatchery project and has already completed a feasibility study. Company officials, however, report that they are currently able to obtain adequate wild pl and do not plan to move ahead with their hatchery project as long as they can continue to do so. Mayasal only harvests at night and delivers the shrimp within hours to the packing plant. It produces "Tikal" brand shrimp which it claims contain no additives or preservatives. The company has a technical cooperation arrangement with an Ecuadorean shrimp farm, El Rosario.[79] Mayasal representatives report that the relationship with El Rosario has worked well. In addition, given El Rosario's experience with hatchery operation, it could prove useful if Mayasal decides to build a hatchery in the future. The company exports to both the United States and the European Community (EC).

Pesca was a former Japanese-Guatemalan joint venture and one of Guatemala's principal shrimp fleet operators.[80] The Japanese company, however, terminated its interests in 1985. Pesca has since expanded its operations into shrimp farming. The company's small farm is located near Puerto San Jose and uses an intensive feeding program and mechanical aerators. Pesca has 13 ha of cement ponds and is Guatemala's first intensive culture operation.[81] It is currently stocking at high densities, 90-130 pl per square meter.[82] The company reports annual yields of about 30 t per ha,[83] which may make it the highest yielding farm in Latin America. Another source reports that the company will report a 1991 harvest of 175 t (appendix C3). This suggests lower yields than estimated by the company, but still quite impressive at over 13 t per hectare.[84] Data on the operating costs required to achieve these high yields, however, are unavailable. Company officials report feed conversion rates of 1.8 and feed is the major cost in the operation.[85] Pesca is producing its own feed in cooperation with a major Guatemalan animal feed producer, Arecasa. The company exports its shrimp to the EC as well as the United States.

Sea Farms of Guatemala: See Granjas Marinas.

VIII. METHODS

Guatemalan growers employ a variety of methods. Many growers are shifting from older, extensive operations to the new semi-intensive operations. In several cases this has necessitated costly redesign and construction projects, primarily dividing large ponds into smaller more manageable units.

Extensive: A few small growers still use extensive methods, but they now account for only a minor part of the harvest. The only important extensive farm was Granjas Marinas. The new Fincas Aquaticas management team, however, is completing major design changes shifting operations to a semi-intensive pond management system.

Semi-intensive: Most Guatemalan farms now employ semi-intensive methods. One estimate suggests that 75-80 percent of Guatemala's ponds are operated on semi-intensive systems.[86] Growers have been forced to adopt relatively sophisticated methods, partially because land prices are fairly high and low-yielding extensive systems would prove unprofitable.[87] Some farms have implemented a variety of adaptations to intensify operations. Many farms, for example, use paddle wheels for aeration. Acapolon and Aguas Marinas de Guatemala in particular are experimenting with intensive innovations.[88] Most growers have nursery ponds to care for pl before stocking growout ponds. Observers vary as to average stocking densities. One observer reports stocking

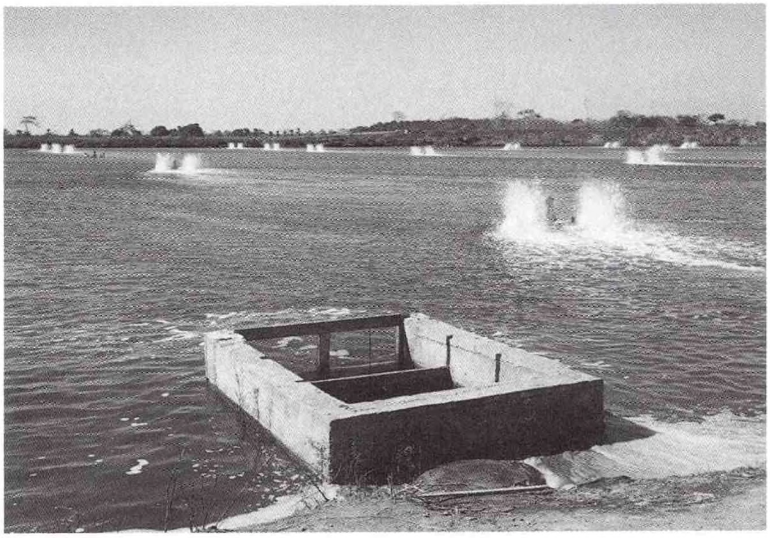

Photo 6.--Guatemala. Many Guatemalan farms are intensifying operations. The use of aerators is becoming increasingly common. © *James Wyban, Oceanic Institute*

densities of 5 to 10 pl per square meter.[89] Another observer insists that stocking densities have been increased sharply in recent years as growers shift to semi-intensive systems.[90] The Guatemalan Government reports substantially higher stocking densities of 20-30 pl per square meter.[91] Growers apply fertilizer and supplemental feed (see "X. Feed") and commonly use daily water exchange rates of about 10 percent.[92] Growers generally conduct harvests after a 4-month growout cycle. Most growers report achieving two to three harvests annually.[93] Some growers, however, are reportedly harvesting on a 2.5 month cycle.[94]

Intensive: The country's first intensive farm was Pesca. It employs several advanced techniques including aeration and extremely high stocking densities. The company claims stocking densities of up to 130 pl per m^2. Acapolon has recently introduced a similar intensive system (with full aeration) for some of its ponds. One report suggests lower stocking densities at Acapolon of 60 pl per m^2.

IX. YIELDS/PRODUCTION COSTS

Yields vary widely from farm to farm. Government sources report that most farms are achieving annual yields from about 0.9-1.5 t per hectare.[95] Another observer estimates 1.0-1.3 t per ha, more or less confirming the Government estimate.[96] One industry representative points out, however, that these estimates are misleading. They are based on pond areas that included FINAQUA ponds which were only fully activated in October 1991, thus depressing the industry average during that year. A calculation of the 650 ha of ponds at the seven farms which were fully active in 1991 would give an annual industry yield of about 2.5 t per hectare.[97]

Most individual semi-intensive farms during 1991 reported crops which if sustained on an annual basis will amount to well over 2 t per year. It is likely that several of the better managed farms will report impressive yields in 1991 and 1992. One industry source, however, suggests that even higher yields are possible.[98] The intensive Pesca farm reports extremely high yields. Acapolon is also reporting impressive yields from its intensive ponds. The profitability of such operations, however, is not yet known.

Only limited data is available on production costs. One leading grower estimates that direct operating costs at a well run semi-intensive farm should be about $2.65 per kilogram (kg) and total operating costs about $3.30 per kilogram.[99] A calculation of total production costs would have to include other factors such as land, construction and infrastructure costs, depreciation, and finance charges. Data on some of the major costs faced by Guatemalan growers is available in appendix E.

X. FEED

The use of supplemental feed is becoming more common as growers increasingly shift to semi-intensive methods. Most growers have for some time fertilized their ponds to create algae blooms. Some use organic fertilizer (poultry and livestock manure), while others use inorganic fertilizers (CO Triple 15 or Urea). An increasing number of growers are now applying supplemental feeding and demand is thus increasing. One 1991 report suggests that the majority of farms are applying supplemental feeds.[100] The relatively small area of ponds, however, limits overall consumption.

Three companies are currently producing feed in Guatemala. **Purina** is the major producer. The company has recently announced plans to make major modifications of its operations to permit the

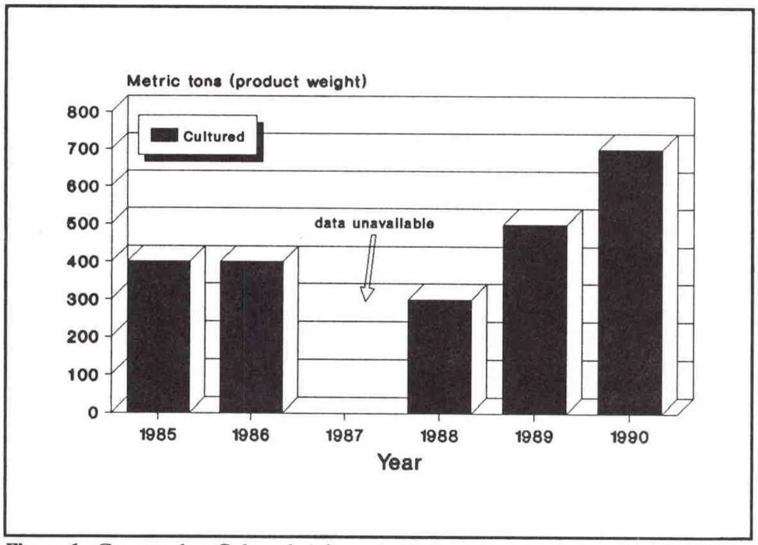

Figure 6.--Guatemala. Cultured shrimp exports have increased sharply since 1988.

production of improved shrimp feed.[101] **Arecasa**, a major Guatemalan poultry operation, also produces shrimp feed. One farm (Pesca) is producing its own feed. Pesca is associated with Arecasa and reports that its feed compares favorably with imported feeds.[102] One report suggests that another company produces "Formulae II" feed, but no further details are available. These companies hope to eventually expand sales to farms throughout Central America. Two other countries plan to begin producing, **ALIANSA** (1992) and **ALIBASA** (mid-1990s).[103] Many observers believe that the small Guatemalan market makes it difficult for domestic feed companies to support the research needed to produce an effective balanced shrimp ration. Purina can draw, however, on the research conducted by Ralston Purina in the United States and by Purina subsidiaries in other Latin American countries.

Some growers have expressed dissatisfaction with locally produced feeds, criticizing both the quality and price.[104] Many growers have reported poor results with domestic feeds. Some have even reported feeds contaminated with insecticides and lesser quality ingredients than advertised.[105]

A few growers import feed from other countries (including Panama, Peru, and the United States), but complain of high prices.[106] Several industry sources insist that dissatisfaction with domestic feed is causing growers to increase imports.[107] One grower reports that farm gate prices during 1991 for imported feed were over $0.75 per kilogram.[108] Several foreign feed companies, including Rangen, Nicovita, and Ziegler, play an important role in Guatemala. One observer insists that all of the more successful growers are importing feed.[109] The Government currently places no restrictions on feed imports. No known published study compares results achieved with domestic and foreign feed, but individual companies have reportedly kept such records.

XI. MARKETS

A. Domestic

Only a small quantity (about 5 percent) of the harvest is marketed domestically. Guatemalan law reportedly requires that 10 percent of overall shrimp production be marketed domestically.

B. Exports

Cultured shrimp now accounts for an important share of Guatemala's total shrimp exports. Export shipments totaled 700 t in 1990, a 40 percent decrease from the 500 t shipped in 1989 (appendix F1 and figure 6). The cultured shipments represented nearly 20 percent of the 2,800 t exported in 1989 (appendix F1-2).[110] The importance of cultured shipments probably increased in 1990, but data is not yet available. Most observers anticipate major increases

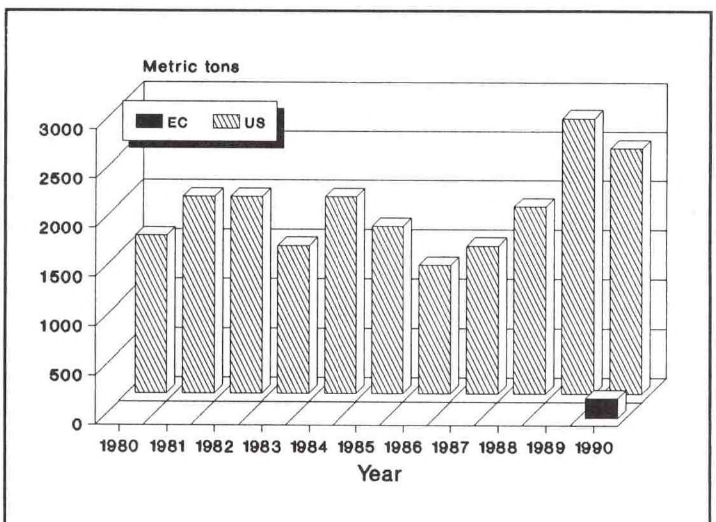

Figure 7.--The United States is the major market for Guatemalan shrimp exporters, but a new European market was opened in 1990.

Photo 7.--Guatemala. Deheading shrimp at the Mayasal processing plant. The product is marketed both in the United States and the EC. © *Gabriel Biguria, Mayasal*

in export shipments as a result of the larger harvests anticipated in 1991 and 1992.

Guatemala's primary shrimp market is the United States (appendix F2 and figure 7). Several companies, however, are opening new European markets.

United States: The harvest is primarily exported to the United States, mostly as frozen heads-off product (appendix F2 and figure 7). No data is available specifically on cultured shipments, but overall Guatemalan shrimp shipments to the United States have been increasing with the expanding pond harvests and reached a record 2,800 t worth over $20 million in 1989. Shipments declined somewhat in 1990 (appendix F3 and figure 8).[111] The 1990 decline may be due to a variety of factors such as a lower trawler catch[112] or the opening of alternative European markets.

Europe: Guatemalan companies initiated shipments to Europe for the first time in 1990 (figure 6). Shipments approached 200 t in 1990, about 80 percent of which was directed at the French market (appendix F4 and figure 9). Various reports suggest that FINAQUA, Mayasal, and Pesca are the principal companies involved, but other companies occasionally participate. Most of the product is shipped whole.[113]

Japan: There are no known shipments to Japan (appendix F3 and figure 7). Future significant shipments to Japan seem unlikely as the Japanese have access to lower priced Chinese cultured white shrimp.[114]

XII. GOVERNMENT ROLE/LEGAL FRAMEWORK

The Government has no known program specially designed to promote the shrimp culture industry.[115] Government agencies, however, offer limited support through various on-going programs. The Government agency responsible for aquaculture is the Dirección Técnica de Pesca y Acuicultura (DITEPESCA).[116] DITEPESCA has a Departamento de Acuicultura which offers extension services through the DIGESEPE regional offices. The extension efforts, however, have focused primarily on domestic food production rather than commercial aquaculture for export production.[117] Each of the eight regional DIGESEPE offices have been assigned an aquaculture specialist. While there is a great need for shrimp culture extension services, no information is available on the effectiveness of the current program. Such a program almost certainly is proving difficult for the Government to administer. Government extension agents who acquire technical background in growout technology could command relatively high salaries in the private sector and the Government would have difficulty retaining their services.

Law 1235 under which fisheries and aquaculture are currently regulated was passed in 1932.[118] The

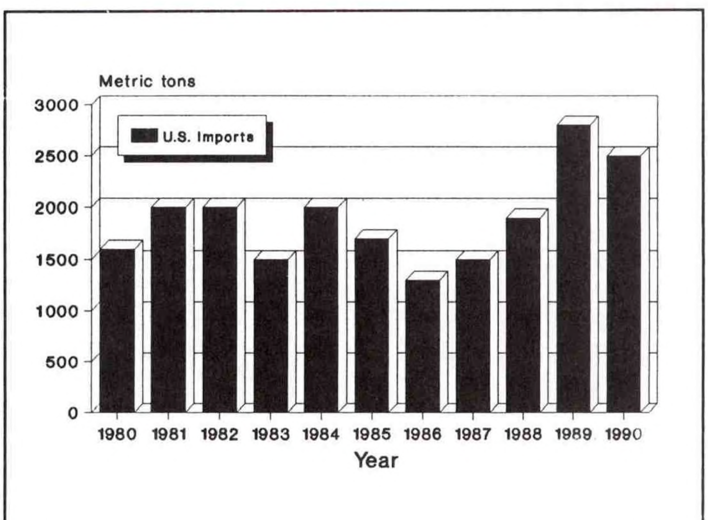

Figure 8.--United States. Shrimp imports from Guatemala set a new record in 1989 because of increased cultured shipments.

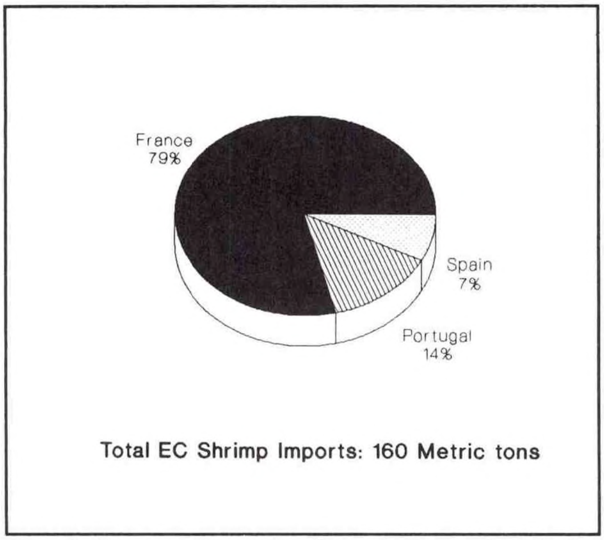

Figure 9.--*European Community. France is Guatemala's principal European market for shrimp.*

law provides some guidance concerning who may participate in the aquaculture industry and who can authorize the use of public waters.[119] Another law also regulates the use of water for aquaculture and coordinates aquaculture licenses with water use rights.[120]

Industry sources insist that Law 1235 is totally unsuited for regulating the country's growing aquaculture industry. Aquaculture did not even exist in Guatemala when the law was passed. Some specific matters dealing with aquaculture have been haphazardly addressed in subsequent legislation.[121] Major issues such as defining aquaculture and regulating farms, pl collection, and hatcheries need to be addressed.

The Guatemalan Congress is now considering a new aquaculture law. Proposals include up-to-date provisions and a promotion program, but have received little support from Guatemalan legislators.[122] Another observer reports that progress is now being made and that the industry is optimistic that a new law will be passed in the near future.[123] While most industry sources agree that a new law is needed, some are concerned about various proposals currently being considered by the Congress. One proposal is to gradually phase out collection of both pl and berried females in the wild. Growers would be required to build hatcheries with sophisticated closed maturation systems, permitting year-round pl production. Such a provision, however, would have a devastating impact on Guatemalan growers at the industry's current stage of development. Most growers are years away from developing such sophisticated hatcheries. Even hatcheries in Ecuador and Panama, with years of experience, often report considerable difficulties with closed cycle maturation.[124]

XIII. CREDIT

Guatemalan shrimp growers do not have access to any special Government credit lines provided to promote the industry. Growers have had to seek credit through commercial banks, which require substantial collateral. The loan terms are generally at 25 percent interest and contain no grace period.[125] Some loans have been obtained through the Banco Centro Americano de Integracion Económico (BCIE), although no details are currently available. Several Guatemalan investors have turned to foreign partners (mostly the United States) to raise investment capital.

XIV. TECHNICAL CAPABILITY

Guatemala has a very small aquaculture industry and few trained technicians with extensive background in shrimp hatchery or growout technology. The country has a very limited capability to train specialists or conduct shrimp culture research. The limited availability of trained technicians impeded operations at early farms. Many current technicians have gained much of their knowledge through on-the-job training. Some Guatemalans have now attended various courses in Japan, Mexico, and the United States. A few have worked in other countries. Small foreign aid projects have provided some technical assistance. (See: "XV. Foreign Assistance.")

Freshwater species: DITEPESCA conducts aquaculture research at its fish culture stations (Amatitlán, La Fragua, San Gerónimo, and San Pedro Pinula). Almost all of the work has focused on finfish (carp and tilapia). DITEPESCA has, with the assistance of the Taiwan aid mission, conducted limited work with freshwater shrimp culture. DITEPESCA obtained *M. rosenbergii* from a hatchery at San Lorenzo, Honduras in 1981. The shrimp were used as broodstock at the Estación Piscícol de Amatitlán. The project was eventually discontinued, however, because of inadequate conditions at the Amatitlán site.[126] DITEPESCA in 1983, built a few ponds for freshwater shrimp along the Caribbean coast with the assistance of Zona Militar officials, but reported negative results.[127]

Marine species: No Guatemalan research institute is known to be investigating marine shrimp culture. The only research currently under way is being conducted by individual growers. Some of the better farms are compiling useful data bases on their growout operations, and keeping detailed statistics on stocking densities, supplemental feeding, and other key variables.[128]

XV. FOREIGN ASSISTANCE

Foreign assistance programs with shrimp culture components have been very limited. The small number of projects have focused mostly on technical transfer. Some training funds have been obtained from UNDP and FAO. While these projects have been helpful, probably more significant has been the contracting of foreign consulting groups by individual growers. Most of the important farms have turned to foreign specialists for technical assistance, mostly U.S. consulting groups. The Taiwan aid mission has provided assistance in freshwater shrimp culture, but this has not proven commercially viable. Guatemala also participates in the 4-year (1991-95) Programa Regional de Apoyo al Desarrollo de la Pesca (PRADEPESCA), a regional fisheries development project. PRADEPESCA has an aquaculture project which includes marine and freshwater shrimp hatchery and grow-out work. PRADEPESCA is also designed to strengthen the individual country fishery agencies and to help encourage training programs. The program is partially financed by the European Community and coordinated by the Organizacion Latinoamericana para el Desarrollo Pesquero (OLDEPESCA).[129]

XVI. OVERVIEW

Guatemalan shrimp growers are reporting considerable progress in developing a small, but profitable industry. Government officials believe that shrimp culture is one of the most promising non-traditional export industries. Estimates on the potential area suitable for shrimp culture vary substantially, but even the most optimistic projections reveal that the area of sites is relatively limited. As a result, the Guatemalan shrimp culture industry will be one of the smallest in Central America. Even so, the current success of growers is encouraging. Many are reporting sharply higher harvests. Several growers appear to be especially open to innovations and introducing new methods. Growing conditions appear favorable and the availability of wild pl seedstock has proven a tremendous advantage. The industry should be able to play an important role in the small Guatemalan economy.

Some observers note constraints which may impair the industry's ability to develop the country's potential. The most significant problems include:

Farm sites: Growers report increasing difficulties finding suitable farm sites. Prices for land with favorable conditions have reportedly increased sharply.

Trained technicians: Growers have access to few trained Guatemalan shrimp culture specialists. The country has virtually no capability of training qualified technicians. This creates problems staffing farms and forces growers to hire more costly foreign experts.

Conflicting interests: Growers face conflicts with fishermen over the use of pl as well with other groups, such as cotton growers, who use various agricultural chemicals (fertilizer and insecticides) which adversely affect water quality.

Credit: Growers report that credit is difficult to obtain and available only at exceedingly high interest rates.

Feed: Some growers see feed as an increasingly serious problem, but other observers believe that expansion programs at Purina and other companies should provide growers with adequate quantities of feed.

Guatemalan growers reported marginal results during the 1980s. Harvests changed little from 1987-89, but growers reported a 1,800 t harvest in 1990 and some observers are projecting 2,400 t in 1991. An increasing number of Guatemalans are gaining experience in shrimp farming and acquiring advanced technical skills by taking courses in foreign countries. Growers should report substantial harvest increases in 1992 as a result of current expansion programs. Further growth should continue during the 1990s and growers could exceed harvests of 7,000 t by the year 2000. Some more optimistic observers are convinced that Guatemalan growers will be able to achieve substantially larger harvests, especially if current trials with intensive systems prove profitable.

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ENDNOTES

SECTION I (Capture Fishery)

1. An excellent, but now dated survey of the fishery is available in Richard K. Keiser, Jr., "An Appraisal of the Shrimp resource of the Guatemalan Pacific Coast," *Boletin Tecnico* (Proyecto Regional de Desarrollo Pesquero en Centroamerica, CCDP/FAO/UNDP: San Salvador, 1971), 35 p.

2. The shark fishery has become especially important. One of the major products is sharkfin and cured shark meat exported primarily to Asian countries. These shipments account for about 5 percent of the country's seafood exports. María Regina Barillas, Executive Coordinator, Gremial de Exportadores de Productos no Tradicionales (Fish and Shellfish Producer's Commission), personal communications, November 28, 1991.

3. More current data on the shrimp fleet is not available. The U.S. Embassy reports that the country's entire commercial fishing fleet consisted of 54 vessels in 1989. U.S. Embassy, Guatemala City, March 9, 1990. Most of those vessels would be shrimp trawlers.

4. "Guatemala," *The Fish Boat*, August 1983, p. 53.

5. Available FAO data on Guatemala does not appear to take in account pond harvests. It is not clear if pond harvests are under-reported or totally excluded. FAO is currently checking with Guatemalan officials to resolve this discrepancy.

6. INFOPESCA, *Noticias Comerciales*, May 20, 1991. Unlike many other countries, Guatemalan seasonal closures clearly differentiate between fishing activities and pl collection. Ann R. Van Houtte, Nicola Bonucci, and William R. Edeson, "Una Revision Preliminar de Legislacion Seliccionada que Norma la Acuicultura," *COPACO Series Pes*, Pes 22 (RLAC/91/12), Santiago 1991, p. 85.

7. Another source reports that the 45 day closure is in May and June. María Regina Barillas, Executive Coordinator, Fish and Shellfish Producer's Commission, Greminal de Exportadores de Productos no Tradicionales, personal communications, December 17, 1991.

8. The authors have received various dates for these closures, but at this time are unable to confirm the precise dates with certainty. See: "V. Postlarval Seedstock: Wild postlarvae" and footnote 33 for more details.

SECTION II (Species)

9. U.S. Embassy, Guatemala City, February 12, 1991. The authors know, however, of no such project even in

the planning stage.

SECTION III (Growing Conditions)

10. Robert Rosenberry, "Guatemala," *World Shrimp Farming*, July 1991, p.8.

11. Some observers believe that Chiapas has the potential to emerge as a major center for Mexico's shrimp culture industry. Other observers offer more qualified assessments. For details see Randolf Wells and Dennis Weidner, "Mexican Shrimp Culture," *International Fishery Reports*, in press.

12. Scott Edward Horton, Operations Manager, Esteromar, personal communications, July 25, 1991.

SECTION IV (Pond Area)

13. The estimate was prepared by Dr. Edward Schura. Rosales Loesseuer, *op. cit.*

14. Ing. Hiroshi Kitani as cited in Victor Hugo Sanchez Ulloa, Direccion Tecnica de Pesca y Acuicultura, "El Cultivo del Camaron en Guatemala," *Simposio Centroamericano Sobre Camaron Cultivado*, Honduras, April 24-26, 1991.

15. David Hudson, *ACAPOLON*, personal communications, July 20, 1990.

16. U.S. Embassy, Guatemala City, August 22, 1990.

17. Barillas, *op. cit.*

18. David Currie, Fincas Aquaticas, personal communications, October 29, 1991.

19. U.S. Embassy, Guatemala City, February 12, 1991.

20. Lic. Fernando Rosales Loessener, Departamento Acuicultura de Guatemala, personal communications, August 28, 1990.

21. Other observers provide somewhat different estimates. Hudson gives a slightly lower estimate of 1,300 ha of ponds. Hudson, *op. cit.* Bob Rosenberry provides a higher estimate, 1,800 ha of ponds. Robert Rosenberry, *World Shrimp Farming, 1990*, January 1991, p. 23.

22. Horton, *op. cit.*, July 25, 1991.

23. Another source suggests a substantially higher utilization rate and estimates that as much as 1,000 ha may be in production. Sanchez, *op. cit.*

24. Dr. Gabriel Biguria O., Mayasal, personal communications, May 8, 1991.

25. Rosales Loessener, *op. cit.*

SECTION V (Postlarval Seedstock)

26. Peter Fairhurst, General Manager, Aqua Industrias Mar Azul, *Aquaculture Digest*, September 1988, p.15.

27. Hatcheries may eventually prove necessary throughout Latin America, but at the beginning stages of the industry's development they represent a substantially increased cost as well as a serious technical challenge. In addition, most growers report that yields from wild pl are superior to those achieved with hatchery-produced postlarvae.

28. Bob Rea, ACAPOLON, personal communications, March 19, 1991.

29. Ing. Hiroshi Kitani as cited in Sanchez, *op. cit.* and Robin Rackowe, personal communications, April 30, 1990.

30. Pl were reportedly available for US$2-3 per 1,000 pl in 1990. U.S. Embassy, Guatemala City, August 22, 1990. A more current report suggests that pl are available for as little as $1 per 1,000. Currie, *op. cit.*, October 29, 1991.

31. Sanchez, *op. cit.*, p. 9.

32. Rodolfo Artiles, Shrimp Farm Consultant, *World Shrimp Farming*, (15.5.LAG) May 1990.

33. The closure was from August 1 to September 30, 1989. Rackowe, *op. cit.* Another source reports that the closure was narrowed to only 45 days in 1990, from September 1 to October 15. Dr. Gabriel Biguria, General Manager, MAYASAL, personal communications, July 3, 1991. Dr. Biguria reports that the same closure was implemented in 1991. Another industry source confirms the a 45-day closure in 1991, from September 1 to October 15. Barillas, *op. cit.* The closure was strongly opposed by industry groups which claimed that there was evidence to substantiate the claim that pl collection was reducing yields of the shrimp fishermen. Peter Fairhurst, Aqua Industrias Mar Azul, personal communications, May 11, 1990.

34. See for example, "Coastal Area Residents Decry Destruction of Marine Life, Mangrove Swamps," *Prensa Libre*, May 20, 1991. p.8.

35. U.S. Embassy, Guatemala City, August 22, 1990.

36. Fairhurst, *Aquaculture Digest*, *op. cit.*

37. Artiles, *op. cit.*

38. Biguria, *op. cit.*, July 3, 1991.

39. Barillas, *op. cit.*

40. Rosales Loessener, *op. cit.*

41. Barillas, *op. cit.*

SECTION VI (Harvest)

42. Belize has virtually no capture fishery and as a result has a high ratio of cultured harvests. For details see Randolf Wells, "Belizian Shrimp Culture," *International Fishery Reports*, in press. Nicaragua reports a small cultured shrimp harvest, but it appears to be mostly primitive operations in enclosed estuaries by artisanal fishermen. Dennis Weidner, "Nicaraguan Shrimp Culture," *International Fishery Reports*, in press.

43. All harvest and yield data has been converted to liveweight equivalencies to facilitate comparisons. For that purpose tailweight was considered to be about 60 percent of liveweight. Some observers report a lower conversion rate. David Hudson, for example, at Acapolon reports 68 percent and that figure was used for conversions at Acapolon.

44. U.S. Embassy, Guatemala City.

45. Rosales Loessener, *op. cit.*

46. Horton, *op. cit.*, July 25, 1991.

47. Tails per pound. U.S. Embassy, Guatemala City, September 28, 1990.

SECTION VII (Farms)

48. Barillas, *op. cit.*

49. U.S. Embassy, Guatemala City, February 12, 1991.

50. INFOPESCA.

51. Domingo Moreira, Pesca, personal communications, July 1, 1991.

52. "New Shrimp Company," *Diario de Centro America,* March 11, 1981, p.5.

53. Sanchez, *op. cit.*, p.3.

54. U.S. Embassy, Guatemala City, November 5, 1980, and "Shrimp International," *Fishing Gazette*, June 1982, p.22.

55. Sanchez, *op. cit.*, p.2.

56. Rosales-Loesseuer, *op. cit.*

57. William R. More, Vice President, Granada Mariculture Technologies, *Aquaculture Digest*, July 1988, p. 18.

58. U.S. Embassy, Guatemala, August 22, 1990.

59. Details on the farm's site and operations are available in Cornelius Mock, "*Penaeid* Shrimp Culture Consultation and Visit," Guatemala, February 16-23, 1987. Further details based on information supplied by Robert W. Rea, Jr, Acapolon, and Dr. Raymond E. Jones is available in "Acapolon Corporation--A Shrimp Farm in Guatemala," *Aquaculture Digest*, July 1987, pp. 10-12.

60. Hudson, *op. cit., July 20, 1990.*

61. Hudson, *op cit.*, July 20, 1990.

62. David Hudson, General Manager, Acapolon, personal communications, November 12, 1991.

63. David Hudson, Acapolon, personal communications, June 27, 1991.

64. Hudson, *op. cit.* November 12, 1991.

65. One source provides a lower pond area of only 35 hectares.

66. Horton, *op. cit.*, July 25, 1991, and Horton, personal communications, December 13, 1991.

67. David Currie, FINAQUA, personal communications, November 10, 1991.

68. David Currie, Fincas Aquaticas, personal communications, November 4, 1991.

69. Currie, *op. cit.*, November 10, 1991.

70. David Currie, General Manager, Fincas Aquaticas, personal communications, July 8, 1991.

71. Currie, *op. cit.*, November 10, 1991.

72. Sanchez, *op. cit.*

73. James Heerin, Shrimp Culture, Inc., item 10.5.36, *Aquaculture Digest*, May 1985.

74. U.S. Embassy, Guatemala City, February 12, 1991.

75. Currie, *op. cit.*

76. Chris Howell, Continental Fisheries, *Aquaculture Digest*, November 1987, p. 16.

77. Gabriel Biguria, Mayasal, personal communications, November 12, 1991.

78. Biguria, *op. cit.*, July 3, 1991.

79. The Ecuadorean group is connected with El Rosario, one of the principal Ecuadorean farm and hatchery complexes. One observer reported that the relationship was an equity partnership. Alexander de Beausset, item 11.5.44, *Aquaculture Digest*, May 1986, p. 18. Mayasal officials report, however, that there is no equity relationship. Bigurira, *op. cit.*, July 3, 1991. For details on El Rosario and the Ecuadorean shrimp culture industry in general, see Tom Revord and Dennis Weidner, "Ecuadorean Shrimp Culture," *International Fishery Reports*, in press.

80. Cesar Moreira, item 11.11.24, *Aquaculture Digest*, November, 1986, p.20.

81. U.S. Embassy, Guatemala City, August 22, 1990, and Morcira, *op. cit.*

82. Barillas, *op. cit.*

83. Moreira, *op. cit.* The company appears to be making substantial progress. Another observer previously reported somewhat lower stocking densities (60 pl per m_2) and yields (15 t per ha). Artiles, *op. cit.* The authors have no confirmation from other sources verifying such high yields.

84. A harvest of 175 t from 13 ha of ponds would mean an annual yield of 13.5 tons (appendix C3).

85. Moreira, *op. cit.*

SECTION VIII (Methods)

86. Dr. Biguria defines semi-intensive as systems with stocking densities of 5-13 pl per square meter. Biguria, *op. cit.*

87. Much of the area being used for shrimp culture is fairly productive agricultural land which sells for relatively high prices. Rosenberry, *op. cit.*

88. Hudson, *op cit.*, July 20, 1990.

89. Artiles, *op. cit.*

90. Barillas, *op. cit.*

91. Sanchez, *op. cit.*

92. Artiles, *op. cit.*

93. One report suggested that two harvests per year are common. U.S. Embassy, Guatemala, February 12, 1991. An industry source reports that most farms are averaging three harvests per year. Horton, *op. cit.* Horton is probably referring to well run semi-intensive farms and not the industry average.

94. Barillas, *op. cit.*

SECTION IX (Yields/Production Costs)

95. Sanchez, *op. cit.*

96. Robin Rackowe, personal communications, April 30, 1990.

97. Currie, *op. cit.*, November 4, 1991.

98. Scott Horton reports that yields average 2.0-2.5 t per ha annually. Horton, *op. cit.*, July 25, 1991. Horton's higher estimate is probably due to the fact that he is referring to the new semi-intensive farms which are increasingly dominating the country's shrimp culture industry.

99. Currie, *op. cit.*, October 29, 1991. It is unknown if this refers to tail weight or whole weight.

SECTION X (Feed)

100. Barillas, *op. cit.*

101. George Chamberlain, Purina, personal communications, May 20, 1991.

102. Moreira, *op. cit.*

103. Barillas, *op. cit.*

104. Artiles, *op. cit.*

105. Horton, *op. cit.* Horton does not identify the specific feed company involved.

106. Hudson, *op. cit.*, July 20, 1990, and Jeff Taylor, Ziegler Brothers Feed, personal communications, April 4, 1991.

107. See for example Artiles, *op. cit.* and Morcira, *op. cit.*

108. Currie, *op. cit.*, October 29, 1991.

109. Horton, *op. cit.*, July 25, 1991.

SECTION XI (Markets)

110. Cultured shipments may well represent a larger portion of exports than shown by the available statistics (appendices E1-2). The fact that the cultured share of the harvest was nearly 30 percent in 1989 (appendix B1) suggests that exports should be more than 30 percent. Almost all of the cultured harvest is export-grade white shrimp, while substantial quantities of the wild catch is small sea bob shrimp (appendix B2), some of which is marketed domestically.

111. Guatemalan and United States statistics do not agree. Guatemalan shrimp production of 3,000 t (liveweight) in 1989 (appendix B1) could not possibly enable exporters to ship 2,800 t (product weight) to the United States (appendix E2). Exports of 2,800 would be primarily tails and require a harvest of about 4,700 t (liveweight). The reason for this discrepancy is unexplained, but may be due to a variety of factors: 1) statistical errors; 2)

failure to include pond harvests in overall production data; or 3) export by Guatemala of shrimp smuggled from neighboring countries.

112. The authors have not yet been able to obtain 1990 Guatemalan catch data.

113. Chamberlain, *op. cit.* Another report confirms that Mayasal is exporting to France. Other companies (FINAQUA, Aquaindustrias Mar Azul, and Pesca) in 1991 are reportedly exporting to France, Germany, and the Canary Islands. Barillas, *op. cit.*

114. For details, see Dennis Weidner, Tom Revord, and Randolf Wells, "Latin American Shrimp Culture," *International Fishery Reports*, in press.

SECTION XII (Government Role/Legal Framework)

115. U.S. Embassy, Guatemala City, August 22, 1990.

116. DITEPESCA is a unit of Dirección General de Servicios Pecuarios (DIGESEPE) which is part of the Ministerio de Agricultura, Ganadería, y Alimentacion.

117. CARE, U.S. AID, and the Peace Corps have supported the extension program. One of the primary objectives was to promote subsistence level farming by rural families. For details see Silvana Castillo, Thomas J. Popma, Ronald P. Phelps, L. Upton Hatch, Terrill R. Hanson, "Family Scale Fish Farming in Guatemala: An Example of Sustainable Aquaculture Development Through National and International Collaboration," *ICA Communicae*, Vol. 12, No. 1-2, December, 1989, pp. 4-5, 8.

118. Ley 1235 Acuerdo Gubernativo de Reglamentos (ley que reglamenta la piscicultura y la pesca).

119. Van Houtte, *op. cit.*, pp. 31-54.

120. Van Houtte, *op. cit.*, pp. 86-87.

121. Ley 176-83.

122. Sanchez, *op. cit.*

123. Hudson, *op. cit., June 27, 1991.* Another report indicates that the Congress is studying a proposal and is currently reviewing it to ensure that it will not adversely affect the industry. Barillas, *op. cit.*

124. For details see Tom Revord and Dennis Weidner, "Ecuadorean Shrimp Culture," *International Fishery Reports*, in press, and Dennis Weidner and Tom Revord, "Panamanian Shrimp Culture," *International Fishery Reports*, (IFR-91/94), December 27, 1991.

SECTION XIII (Credit)

125. One observer reported that quetzal rates during 1991 varied from 22-25 percent per annum. Currie, *op. cit.*, October 29, 1991.

SECTION XIV (Technical Capability)

126. Sanchez, *op. cit.*

127. Sanchez, *op. cit.*

128. Raymond E. Jones, Botanist, personal communications, August 4, 1987.

SECTION XV (Foreign Assistance)

129. Julio César Aizprúa, "Países centroamericanos valorizan sector pesquero," *La Prensa*, September 12, 1991; OLDEPESCA, "Programa Regional de Apoyo al Desarrollo de la Pesca en el Istmo Centroamericano: Plan de Trabajo, Primer Año de Operaciones," July 9, 1991, pp. 40-52, and Armando Martínez Valdés, Asistente Ejecutivo, OLDEPESCA, personal communications, August 27, 1991.

APPENDICES

Appendix A.--Addresses

Government Agency

Departamento Acuicultura
Dirección Técnica de Pesca y Acuicultura (DITEPESCA)
Dirección General de Servicios Pecuarios (DIGESEPE)
Ministerio de Agricultura, Ganadería, y Alimentacion
Kilometro 22, Carretera al Pacífico
Barcena, Villa Nueva
Guatemala
Telephone: (031) 2014/17

Trade Group

Asociación de Criaderos de Camarón
Address unavailable
Guatemala City
Guatemala

Comisión de Recursos Hidrobiológicos
Gremial de Exportadores de Productos no Tradicionales
Cámara de Industrias de Guatemala
Edificio Cámara de Industria
Nivel 6, Ruta 6, 9-21, Zona 4
Guatemala City 01009
Guatemala
Telephone: (502-2) 346-872
FAX: (502-2) 323-590

Farms

Acapolon
Farm: Champerico, Retalhuleu
Office: 15 Ave. 19-04, zona 11
Guatemala City
Guatemala
Telephone: 680668
FAX: 316267

Acuicultura Industrial
Farm: El Ahumado, Santa Rosa
Office: 11 Ave. 19-29, zona 10
Guatemala City
Guatemala

Agromaricultura
Salinas, Chape, Retalhuleu
Guatemala
Telephone: 311957

Agromarinas Acapan
Champerico, Retalhuleu
Guatemala
Telephone: 910716

Aqua Industrias Mar Azul
Champerico, Retalhuleu
Diagonal 6 10-31, zona 10
Guatemala City
Guatemala
Telephone: 321211
FAX: 347-238

Aguas Marinas de Guatemala
Farm: Tahuesco, Suchitepecue
Office: 10ª Ave. 33-02, zona 11
Guatemala City
Guatemala

Comarpa
Farm: Buena Vista, Escuintla
Office: 6ª Ave. 33-69, zona 11
Guatemala City
Guatemala

Desarrollo de Proyectos Maritimos
Farm: Sipacate, Escuintla
Office: Ave. Reforma 10-00, zona 9
Guatemala City
Guatemala

Esteromar
Farm: Iztapa, Escuintla
Office: Via 1, No. 4-88, zona 4
01004 Guatemala City
Guatemala
Telephone: 348221, 318026
FAX: (5022) 316267

Fincas Aquaticas
Diagonal 6, 10-31, zona 10
Guatemala City
Guatemala
Telephone: (502-2) 321-211, 346-572
FAX: (502-2) 346-573

Fincas Aquaticas
International mailing address
444 Brickell Avenue
Suite 51-185
Miami, Florida 33131-2492

Granjas Marinas
Farm: La Chorrera, Retalhuleu
Office: 2ª Ave. 3-38, zona 9
Guatemala City
Guatemala

Indumar
Address unavailable

Marpasa
Champerico, Retalhuleu
Guatemala
Telephone: 693807

Mayasal
Farm: Las Lisas, Santa Rosa
Office: 7ª Ave. 3-74, zona 9
Guatemala City
Guatemala

Mi Cielo
Iztapa, Escuintla
Guatemala
Telephone: 316221

Pesca
Farm: Near Puerto San Jose
Office: 6ª Av. 33-69, zona 11
Guatemala City
Guatemala
Telephone: 767411/767415
FAX: 762897

Tropimar
Farm: Ginebra, Santa Rosa
Office: Carretera Poosv. 37-31, zona 11
Guatemala City
Guatemala

XELMAR
4ª Ave. 3-10, zona 10
Guatemala City
Guatemala
Telephone: 346-203

Feed Companies

ALIANSA
Address unavailable

ALIBASA
Address unavailable

ARECASA
Address unavailable

Purina
Address unavailable

Appendix B1.--Guatemala. Wild and cultured shrimp harvest, 1980-93

Year	Pond Harvest	Wild#	Total	Portion Cultured
	1,000 Metric tons*			Percent
1980	-	2.2	2.2	-
1981	-	2.8	2.8	-
1982	Negl	2.5	2.5	-
1983	0.1	1.6	1.7	6
1984	0.3	2.3	2.6	12
1985	0.5	1.9	2.4	21
1986	0.6	1.3	1.9	32
1987	0.8	1.1	1.9	42
1988	0.8	1.6	2.4	33
1989	0.8	2.2	3.0	27
1990	1.8**	NA	NA	NA
1991	2.4P	NA	NA	NA
1992	3.5P	NA	NA	NA
1993	4.0P	NA	NA	NA

FAO data theoretically includes cultured shrimp, but the quantities cited suggest that the Government agency supplying data to FAO has omitted or under-reported cultured harvests. Consultations with FAO statisticians suggest that the data in the Yearbook of Fishery Statistics probably do not include cultured shrimp. The authors have asked Guatemalan officials for detailed statistics, but have received no reply.
* Liveweight
** Some sources suggest lower harvests. The U.S. Embassy reported a 1990 harvest of only 1,060 tons.
NA - Not available
P - Projection
Sources: INFOPESCA (1985-88 cultured data); INFOFISH International, April 1990 (1989 cultured data); appendix C1 (1990 cultured data); Scott Edward Horton, Esteromar, personal communications, July 25, 1991 (1991 cultured projection); Fernando Rosales Loessener, DITEPESCA, personal communications, January 10, 1991, and various individual company reports (1991-93 projections); FAO. Yearbook of Fishery Statistics, various years (total shrimp harvest data).

Appendix B2.--Guatemala. Shrimp harvest, by species, 1980-89

Year	Species*				Total**
	White#	Yellowleg	Crystal	Seabob	
	1,000 Metric tons				
1980	0.4	0.5	0.1	1.2	2.2
1981	0.8	0.4	Negl	1.5	2.8
1982	0.6	0.5	0.1	1.3	2.5
1983	0.4	0.3	0.1	0.9	1.6
1984	0.5	0.4	0.1	1.4	2.3
1985	0.5	0.4	0.1	0.9	1.9
1986	0.3	0.1	Negl	0.8	1.3
1987	0.4	0.1	Negl	0.6	1.1
1988	0.4	0.2	0.1	0.9	1.6
1989	0.5	0.2	Negl	1.4	2.2

* White/blanco: Penaeus vannamei and P. stylirostris
  Yellow leg or brown/pardo: P. californiensis
  Crystal/rojo: P. brevirostris
  Seabob/tití: Xiphopenaeus, Trachypenaeus spp.
** Totals may not agree due to rounding.
# These statistics do not appear to reflect the expanding cultured harvests. The reason for this discrepancy is unexplained.
Source: INFOPESCA, Noticias Comerciales, October 20, 1990.

Appendix B3A.--Central America. Shrimp harvest, capture fishery and pond culture, 1989

Country	Harvest		Total	Portion Cultured
	Capture	Culture		
	1,000 Metric tons			Percent
Honduras	1.9	3.2	5.1	63
Belize	0.2	0.1	0.3	50
Nicaragua	1.3*	0.6	1.9	32
Guatemala	**2.2**	**0.8**	**3.0**	**27**
Panama	8.6	2.3	10.9	21
El Salvador	3.6	0.1E	3.7	3
Costa Rica	8.9	0.2	9.1	2
Total	26.7	7.3	34.0	21

* Mismanagement by the Sandinistas has badly depressed the country's fisheries catch. Most observers anticipate substantial increases in 1992 and 1993 as a result of the current privatization program.
E - Estimated
Sources: Various country reports.

Appendix B3B.--Central America. Shrimp harvest, capture fishery and pond culture, 1990

Country	Harvest		Total	Portioned Cultured
	Capture	Culture		
	1,000 Metric tons			Percent
Honduras	NA	5.5	NA	NA
Panama	NA	2.2	NA	NA
Guatemala	**NA**	**1.8***	**NA**	**NA**
Nicaragua	NA	0.6E	NA	NA
Costa Rica	NA	0.3	NA	NA
El Salvador	NA	0.1E	NA	NA
Belize	NA	0.1E	NA	NA
Total	NA	10.4	NA	NA

E - Estimated
* Harvest increases planned for 1991 may enable Guatemalan growers to exceed Panamanian harvests, although it is difficult to project because data on Panama has proven difficult to obtain.
Sources: Various country reports.

Appendix C1.--Guatemala. Marine shrimp farms, 1990.

Company	Ponds	Harvests
	Hectares	Metric tons
Acapolon	91♦	450
Agro Marinas de Guatemala	80	NA
Aqua Industrias Mar Azul	101	200
Aguas Marinas de Guatemala	80	200
Cordero Farm	30	NA*
Desarrollo de Proyectos Maritimos	14	NA
Esteromar	52	164
Fincas Aquaticas (FINAQUA)	420	270
Granjas Marinas**	NA	NA
Indumar	35	NA
Marpasa	75	110
Mayasal	200	350
Pesca	10♦♦	NA
Tropimar/XELMAR	23	30
Total♦	1,211	1,774

NA - Not available
♦ Expanded to 146 ha in 1991
♦♦ While the area of ponds is small, the intensive system should result in a substantial harvest.
♦♦♦ Does not include farms for which data is not available. Actual totals will be somewhat larger.
* The U.S. Embassy reports 204 t, but given the small area of ponds such a large harvest appears excessive.
** Closed, but leasing farms to FINAQUA. Sometimes referred to as Sea Farms of Guatemala.
Note: Data base altered by some direct communications from individual farms.
Sources: U.S. Embassy, Guatemala City, February 12, 1991. David Hudson, ACAPOLON, personal communications, July 1990 and June 27, 1991; Dr. Gabriel Biguria, MAYASAL, personal communications, May 8 and July 3, 1991, and Scott Edward Horton, Operations Manager, Esteromar, personal communications, December 13, 1991.

Appendix C2.--Guatemala. Marine shrimp farms, 1990.

Company	Ponds		Harvests	Location
	Built	Potential*		
	Hectares		Metric tons	
Acapolon	91♦	150	450	Champerico, Retalhuleu
Acuicultura Industrial	10	50	NA	El Ahumado, Santa Rosa
Agromaricultura	50	NA	NA	Salinas, Chape, Retalhuleu
Agro Marinas de Guatemala	35	NA	NA	Champerico, Retalhuleu
Aqua Industrias Mar Azul	101	264	NA	Champerico, Retalhuleu
Aguas Marinas de Guatemala	100	250	NA	Tahuesco, Suchitepecue
Comarpa	10	NA	NA	Buena Vista, Escuintla
Desarrollo de Proyectos Maritimos	45	22	NA	Sipacate, Escuintla
Esteromar/Mi Cielo	40	NA	NA	Iztapa, Escuintla
Fincas Aquaticas (FINAQUA)	NA**	NA	NA	NA
Granjas Marinas#	450	100	NA	La Chorrera, Retalhuleu
Indumar	NA	NA	NA	NA
Marpasa	100	350	NA	Champerico, Retalhuleu
Mayasal	200	20	NA	Las Lisas, Santa Rosa
Pesca	10	NA	NA	Near Puerto San Jose
Tropimar	28	20	NA	Ginebra, Santa Rosa
Total♦♦	1,270	1,226	NA	

NA - Not available
♦ Expanded to 146 ha in 1991.
♦♦ Does not include farms for which data is not available. Actual totals will be somewhat larger.
* Additional area of ponds which could be built.
** Reportedly leasing Granjas Marinas ponds.
# Closed, but leasing ponds to FINAQUA. Sometimes referred to as Sea Farms of Guatemala.
Note: Data base altered by some direct communications from individual farms.
Source: Victor Hugo Sanchez Ulloa, Direccion Tecnica de Pesca y Acuicultura, "El Cultivo del Camaron en Guatemala," Simposio Centroamericano Sobre Camaron Cultivado, Honduras, April 24-26, 1991.

Appendix C3A.--Guatemala. Marine shrimp farms, arranged alphabetically 1991.

Company	Ponds		Harvests
	Built	Active	
	Hectares		Metric tons
Acapolon	146	122*	667♦
Acapan	15♦	-	-
Agroindustrias Chapan	27♦	-	-
Agro Marinas de Guatemala	80	30	40
Esteromar	52	NA	218
Finca El Chile	25	5	5
FINAQUA	250	100**	400
Indumar	35♦♦	-	-
Aqua Industrias Mar Azul	135	NA	370
Marpasa	75	NA	150
Mayasal	240	NA	250
Pesca	13	NA	175
Proy. Maritimos	14	NA	12
Tropimar	20	NA	40
Total	1,127	774	2,427

* Another 25 ha of ponds should be operational by mid-1992.
♦ Recent reports from the company provide this updated figure.
David Hudson, General Manager, Acapolon, November 12, 1991.
♦♦ Closed
** A substantial redesign project is under way at the ponds leased from Granjas Marinas. The company hopes to have all 445 ha of ponds operational by November 1991.
Source: Scott Edward Horton, Operations Manager, Esteromar, personal communications, July 25 and December 13, 1991.

Appendix C3B.--Guatemala. Marine shrimp farms, arranged by order of importance 1991.

Company	Ponds		Harvests
	Built	Active	
	Hectares		Metric tons
Acapolon	146	122*	667♦
FINAQUA	250	100**	400
Mayasal	240	NA	370
Aqua Industrias Mar Azul	135	NA	350
Esteromar	52	NA	218
Pesca	13	NA	175
Marpasa	75	NA	150
Agro Marinas de Guatemala	80	30	40
Tropimar	20	NA	40
Proy. Maritimos	14	NA	12
Finca El Chile	25	5	5
Acapan	15♦	-	-
Agroindustrias Chapan	27♦	-	-
Indumar	35♦	-	-
Total	1,127	774	2,427

* Another 25 ha of ponds should be operational by mid-1992.
♦ Recent reports from the company provide this updated figure.
David Hudson, General Manager, Acapolon, November 12, 1991.
♦♦ Closed
** A substantial redesign project is under way at the ponds leased from Granjas Marinas. The company hopes to have all 445 ha of ponds operational by November 1991.
Source: Scott Edward Horton, Operations Manager, Esteromar, personal communications, July 25 and December 13, 1991.

Appendix D.--Guatemala. Shrimp hatcheries

Species/Location	Operator	Status
Freshwater		
Amatitlan	Estación Piscícol	Closed
Champerico	EAG	Closed (1982)
Retalhuleu	Private	In production (1987)*
Santa Rosa	Private	In production (1987)*
NA	CEMA	In production (1991)
Marine		
Amatitlan	Government	Proposed (1987)*
Champerico	Marpasa	Closed (1991)**
Retalhuleu	Private	Under construction (1987)***

* More recent data not available.
** No details are available, but the small Marpasa hatchery is not known to have actually produced postlarvae.
*** More recent data not available, but several observers have noted that as of 1991 there are no marine shrimp hatcheries in Guatemala.
Source: U.S. Embassy, Guatemala City, June 8, 1987.

Appendix E.--Guatemala. Cost of major shrimp culture inputs, 1991

Factor	Cost
	US$
Coastal land	1,500-3,000 per hectare
Loans	NA*
Seedstock	1 per 1,000 postlarvae**
Feed	0.77 per kilogram♦
Labor♦♦	80-100 per month

* Rates for quetzal loans are about 20-25 percent per annum
** These are some of the lowest price levels in Latin America.
♦ Imported feed, farm gate price
♦♦ Unskilled worker
Source: David Currie, Fincas Aquaticas, personal communication, October 29, 1991.

Appendix F1.--Guatemala. Exports of cultured shrimp, 1985-90

Year	Quantity*
	1,000 Metric Tons**
1985	0.4
1986	0.4
1987	NA
1988	0.3
1989	0.5
1990	0.7

* It is unclear if the two data bases (the U.S. Embassy and Sanchez) are compatible. The U.S. Embassy estimates may be high based on available harvest data.
** Product weight (mostly tails)
Sources : U.S. Embassy, Guatemala City, June 8, 1987 (1985-86 data) and Victor Hugo Sanchez Ulloa, Direccion Tecnica de Pesca y Acuicultura, "El Cultivo del Camaron en Guatemala," Simposio Centroamericano Sobre Camaron Cultivado, Honduras, April 24-26, 1991 (1988-90 data).

Appendix F2.--Guatemala. Shrimp exports by country, 1980-90

Year	Country U.S.	Country E.C*	Country Japan	Total
	1,000 Metric tons**			
1980	1.6	-	-	1.6
1981	2.0	-	-	2.0
1982	2.0	-	-	2.0
1983	1.5	-	-	1.5
1984	2.0	-	-	2.0
1985	1.7	-	-	1.7
1986	1.3	-	-	1.3
1987	1.5	-	-	1.5
1988	1.9	-	-	1.9
1989	2.8	-	-	2.8
1990	2.5	0.2	-	2.7

* Includes Spanish data beginning in 1986. For country breakdown see Appendix F4.
** Product weight
Sources: U.S. Bureau of the Census, EC NIMEXE, and the Japan Tariff Association.

Appendix F3.--United States. Shrimp imports from Guatemala, 1980-91.

Year	Imports Quantity	Imports Value
	1,000 Metric tons*	US$ Million
1980	1.6	12.1
1981	2.0	14.5
1982	2.0	16.7
1983	1.5	13.5
1984	2.0	16.1
1985	1.7	13.0
1986	1.3	10.0
1987	1.5	13.3
1988	1.9	14.4
1989	2.8	20.3
1990	2.5	17.5
1991	2.6P	NA

* Product weight (mostly tails)
P - Projection, actual shipments through September totaled 1,552 tons.
Note: The quantities imported from Guatemala (if adjusted to liveweight equivalencies) exceed the quantities caught/harvested (appendix B1). The reason for this discrepancy is unexplained. Possible explanations are discussed in "XI. Markets: Exports."
Source: U.S. Bureau of the Census.

Appendix F4.--European Community. Shrimp imports by country, 1989-90

Year	Country France	Country Portugal	Country Spain	Total
	Metric tons*			
1989	-	-	-	-
1990	127	22	12	161

* Product weight
Sources: EC NIMEXE.

3.5

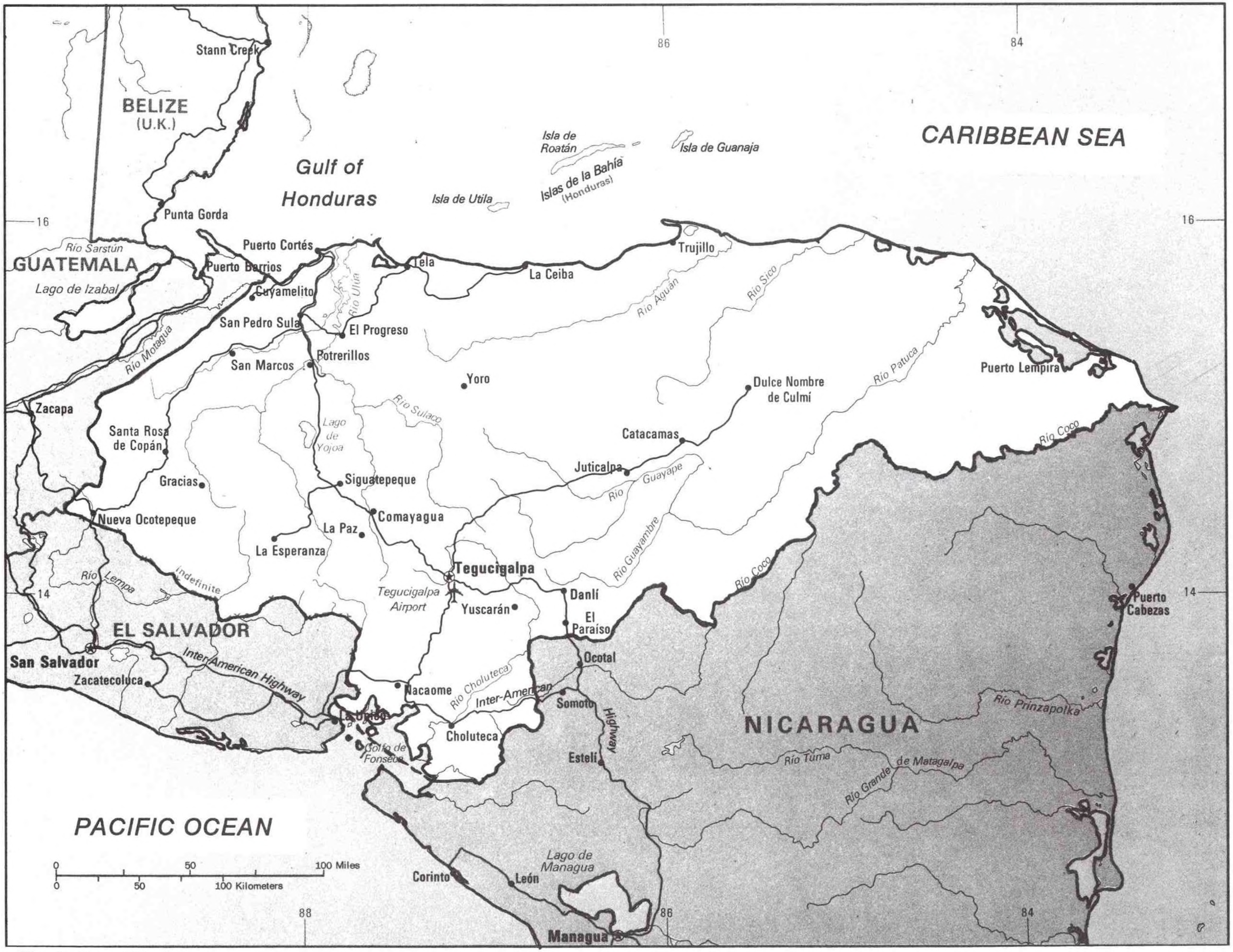
HONDURAS

Honduran shrimp growers have been experimenting with shrimp culture since the late 1960s. Early efforts achieved only mixed results. The first full-scale commercial operations did not begin until 1980. The early farms encountered a variety of problems, but by 1986 growers were achieving very encouraging results and several groups initiated major pond construction programs in 1987. Several companies expanded existing operations or opened new farms. Growers reported sharply increasing harvests which totaled 3,400 metric tons in 1988. Harvests declined in 1989 because of postlarval shortages, but observers report an improved 1990 harvest of about 5,500 tons. The rapidly expanding shrimp culture industry is centered in the south along the Pacific coast. The potential along the much more extensive Caribbean (northern) coast is not yet fully assessed. Pond harvests are more than making up for declining trawler catches which are mostly taken in the Caribbean. Honduras is emerging as the leading shrimp culture industry in Central America. Although growers face some difficulties, especially with obtaining postlarval seedstock, local observers are optimistic and believe the industry will substantially increase harvests during the 1990s making it one of Honduras' major sources of export earnings.

CONTENTS

I. SHRIMP FISHERY

The Honduran shrimp industry until the mid-1980s was dominated by the commercial trawl fishery. The fishery is primarily conducted in the north, off the country's isolated Caribbean coast. Six companies, mostly based in the Bay Islands, deploy about 270 vessels which trawl shrimp and trap lobster. The primary Caribbean ports are Puerto Cortés, Tela, La Ceiba, Utila, Trujillo, Puerto Castillo, and the Barra de Caratasca (Map). Most of the catch is taken from July to February and consists of northern pink shrimp (*Penaeus duorarum*), northern brown shrimp (*P. aztecus*), southern white shrimp (*P. schmitti*), northern white shrimp (*P. setiferus*), Atlantic seabobs (*Xiphopenaeus kroyeri*), and various other



Map 1.--Map of Honduras.

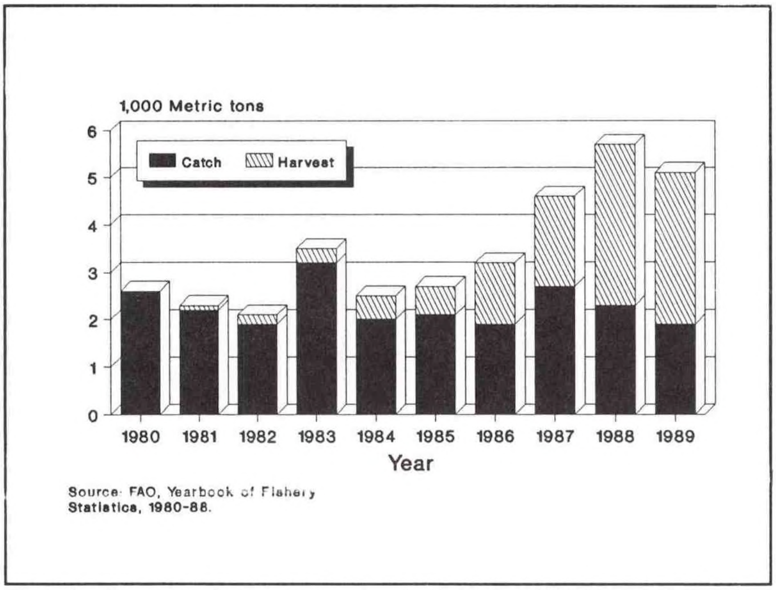


Figure 1.-- *Honduras. Shrimp catches have declined since 1980, but have been more than replaced with expanding pond harvests.*

small species of limited commercial value (*Metapenaeus sp.*). Fishing in the south, along the Pacific (Gulf of Fonseca) coast is a relatively small-scale operation, limited to the area around San Lorenzo and Isla Ratones. Honduran fishermen achieved a record shrimp catch in 1983, but have since reported generally declining catches (appendix B and figure 1). Honduran observers believe that stocks are being overfished.[1]

II. CLIMATE AND GEOGRAPHY

Honduras is bordered by Guatemala, El Salvador, and Nicaragua. It is the second largest Central American country, exceeded in area only by Nicaragua. The basic topographical characteristic is a mountainous interior and relatively narrow coastal plains. Honduras is roughly triangular in outline (Map). Both coasts are primarily alluvial coastal plains with narrow river valleys that penetrate far inland, particularly along the northern coast. The long **northern coast** fronts on the Caribbean and is about 645 kilometers (km), extending from the mouth of the Río Motagua in the west to mouth of the Rio Coco (Cabo Gracias a Dios) in the west. Two major mountain ranges run through Honduras from north to south. The small **southern coast**, forming the apex of the Honduran triangle extends for only about 80 km along the Gulf of Fonseca.

The climate ranges from temperate in the mountainous interior to tropical along the coastal lowlands. The dry season lasts from December[2] to May and seriously affects the southern area of the country where the shrimp industry is centered. The southern coast receives more rainfall than the interior, but less than the northern coast. During the southern coast dry season the land becomes parched and dusty.

III. POND AREA

Estimates vary widely as to the total area suitable for shrimp culture along Honduras' southern (Gulf of Fonseca/Pacific) and northern (Caribbean) coasts.

Southern: Honduras does not have a coast directly on the Pacific, but does have access through the Gulf of Fonseca which it shares with neighboring El Salvador and Nicaragua. The overall Gulf of Fonseca coast is about 80 km and includes the southern provinces of Valle (western area) and Choluteca (eastern area). The U.S. Embassy in Tegucigalpa estimates that about 23,000 hectares (ha) are suitable for shrimp culture in the Gulf of Fonseca/southern Honduras area.[3] Observers caution that such estimates may be high. Detailed surveys have not been conducted to fully assess water quality, salinity, soil types, pH levels, mangrove density, and other factors.

Northern: No reliable estimates exist of the area suitable for culture along the country's extensive Caribbean coast. One report suggested that about 10,000 ha may be suitable for pond construction.[4] Given the extent of the coast, a substantially larger area may eventually prove suitable for shrimp culture. The Caribbean coast, however, is lightly populated and has only limited infrastructure. As a result, development at isolated sites may prove difficult and expensive. Caribbean shrimp culture is further complicated by the absence of a suitable indigenous species.

The Government has concentrated its efforts on shrimp culture along the southern (Gulf of Fonseca) area. It has authorized the development of 13,000 ha of coastal land, all along the Gulf of Fonseca coast to build shrimp farms.[5] The existing pond area could thus double even without further government authorizations, although information on the suitability of these authorized sites is unavailable. The Government has made no effort to promote the shrimp culture industry along the northern (Caribbean) coast. Officials apparently want to take a more orderly approach to development along the northern coast than occurred along the southern coast. Government officials believe that the development along the Gulf of Fonseca was too rapid and inadequately controlled, resulting in a variety of social and environmental problems. The Government apparently wants to ensure that the industry's development does not impair the currently pristine northern (Caribbean) coastline. Officials have not yet, however, developed the appropriate regulations or revised the system for granting concessions.

Most of Honduras' shrimp ponds have been built in the past few years. As recently as 1984 there were only about 300 ha of ponds (appendix B). The area of ponds increased slowly until 1987 when several companies began important construction programs. Growers had constructed approximately 5,000 ha of ponds by 1989 and over 4,000 ha were operational (appendix B and D). Local sources estimate that about 6,000 ha of ponds were in operation at the end of 1990.[6] One expert estimates that the area of pond will total 7,200 ha by the end of 1991.[7] An optimistic observer believes that pond area could reach as much as 15,000 ha by 1995 (figure 2).

Honduran commercial farms are all located along the southern (Gulf of Fonseca/Pacific) coast, where a natural supply of *P. vannamei* postlarvae (pl) and a variety of environmental conditions (large tidal exchanges, extensive but little used salt flats, and other factors) have attracted shrimp growers. Scattered reports indicate small farms have been opened along the northern (Caribbean) coast, but no details are available on such farms. There are no known commercial operations along the northern coast.

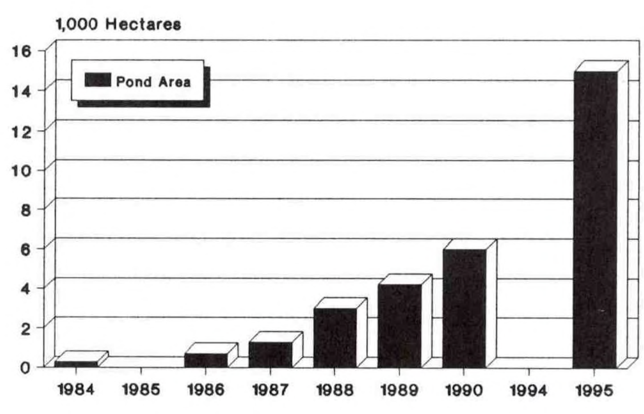


Figure 2.--*Honduras. The area of ponds began to increase sharply in 1987 when several growers began important expansion programs.*

IV. CONDITIONS

A. Environmental

Some observers report very favorable growing conditions along the Gulf of Fonseca. One observer is convinced that "the potential is tremendous" in the Gulf's thousands of ha of salt flats.[8] Observers also mention, however, a variety of environmental problems in the area where the industry is currently centered. Growers report three major environmental concerns affecting aquaculture. First, **clearing mangroves** is detrimental to the estuarine ecosystem. The Corporación Hondureña de Desarrollo Forestal believes that about half of the country's 90,000 ha of mangroves have been destroyed.[9] Growers point out that most of the damage to the mangroves has been done by artisanal salt makers who still produce salt by boiling water, using the mangrove wood as fuel.[10] Nonetheless, shrimp growers are currently dependent on that ecosystem for, among other matters, their supply of pl to stock ponds. Second, **high salinity levels**, especially during the December-May dry season, result from the high evaporation rates and reduced freshwater flow in the rivers. Excessive salinity levels can cause high mortality rates in ponds. Some growers have reported losses of up to 60 percent.[11] Third, **low pH (acidity) levels** associated with red mangroves reduce shrimp survival and growth rates. This is primarily a site problem since soil pH levels vary widely along the Gulf of Fonseca coast. Growers report that sites with low soil pH levels can experience disastrous die offs, especially when water salinity rises to abnormally high levels.

Little information is available concerning environmental conditions along the Caribbean. The fact that no commercial farms have been built there suggests less than ideal conditions.

Preliminary information suggests that much of the coast along the Caribbean is lined with mangroves, so low pH levels may be present.[12] Many other factors, however, are involved. The lack of an indigenous species readily suited for culture is probably the major problem. (See "Species".) Limited infrastructure (roads and utilities) along the northern (Caribbean) coast is another major impediment which would substantially raise construction and operating costs.

B. Economic

Honduran shrimp growers have one major advantage over growers in other Central American countries, which is the ready availability of inexpensive energy. A large portion of the country's energy needs are supplied by the massive El Cajon hydro-electric project. The El Cajon facility was designed by a Czech group and supplies electrical energy domestically at very low rates. This means that pumping water can be accomplished less expensively in Honduras than in some other countries.[13] As shrimp growers increasingly shift to more intensive methods, this is becoming an increasingly important factor.

V. SPECIES

Honduran growers have primarily focussed on *P. vannamei*, the species preferred by most Latin American shrimp growers. None of the principal species which occur off Honduras have proven suitable for pond culture (See "Shrimp Fishery.") Informal trials have been conducted with other species, notably *P. occidentalis*, *P. schmitti*, and *P. stylirostris*. Early growers were generally disappointed with growth and survival rates of all three species[14]. As a result most growers want *P. vannamei*, although some will use *P. stylirostris*, when *P. vannamei* pl are not available.[15] The reliance on *P. vannamei* pl creates problems for growers. First, there are only **limited quantities** of *P. vannamei* pl which can be collected along Honduras' small Gulf of Fonseca coast. Two, the **availability** of wild *P. vannamei* pl is limited to growers located along the southern (Gulf of Fonseca) coast. This means that growers trying to locate farms along the much more extensive northern (Caribbean) coast will face a much more difficult problem obtaining postlarval seedstock.

The industry's reliance on *P. vannamei* created particularly severe problems beginning in late 1988 when growers reported difficulties obtaining adequate supplies of *P. vannamei* pl to stock the rapidly expanding number of ponds. Some observers in 1989 and early 1990 speculated that *P. stylirostris* was replacing *P. vannamei* in the wild.[16] If accurate, this could have meant that Honduran growers would face increasing difficulties in stocking their ponds. Growers reported, however, a better appearance of *P. vannamei* pl in 1990.[17] Some observers have concluded that the variability in the wild stocks of specific species is due to normal periodic fluctuations reflecting a variety of climatic and environmental factors.[18] Preliminary reports from Honduras in early 1991, suggest that both *P. vannamei* and *P. stylirostris* pl are extremely scarce.[19] (See "Postlarval Supplies.") As a result, growers are becoming increasingly concerned about future supplies of *P. vannamei* postlarval seedstock.

VI. POSTLARVAL SUPPLIES

Growers obtain their postlarval seedstock from the Gulf of Fonseca. Pl collectors are mostly artisanal fishermen using many of the methods developed in Ecuador. Most of the Honduran collection, however, is conducted in shallow estuaries.[20] Some effort has been made to expand the collection area and to improve collection methods. One observer reported that berried females were being gathered in Nicaraguan waters.[21] Observers report that growers have been able to purchase pl very inexpensively from the collectors, as low as $0.50 per 1,000 postlarvae.[22] Some observers believe that the quantity of pl delivered by the artisanal fishermen could be substantially increased if their collection and handling procedures could be improved.[23] The most abundant species is reportedly *P. occidentalis;* however, since that species does not perform well in ponds, much of the available pl is unusable. The preferred *P. vannamei* and *P. stylirostris* species are less abundant, sharply limiting the ability of growers to rely on wild pl stocks.

Growers are becoming increasingly concerned about obtaining pl throughout the year as the pond area expands and pl demand increases. Pl availability is partially dependent on the rainy season. The length and intensity of the rainy season creates sharp seasonal variations in pl availability. Pl in 1989, for example, did not become available in significant numbers until May due to an abnormally severe 1988

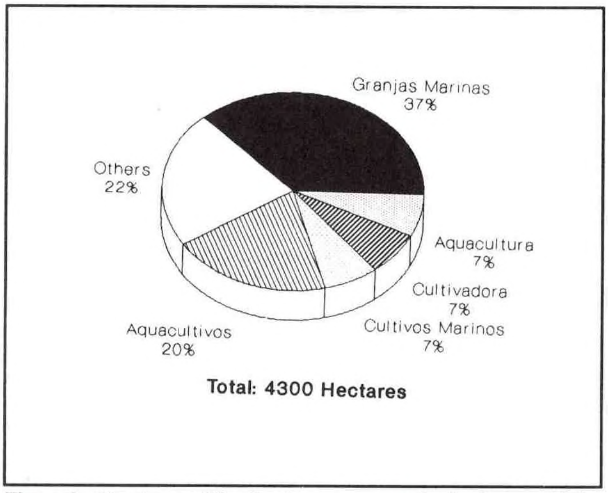


Figure 3.--Honduras. The five largest companies had around 75 percent of the total pond area in 1990.

dry season. In addition, the portion of the preferred *P. vannamei* pl declined. The resulting pl shortage was one of the principal factors in the reduced 1989 harvest (appendix B). Some growers are attempting to compensate for the seasonal pl shortage by buying large quantities of pl when they are abundant and maintaining them in nursery ponds at high density until needed for stocking. Other groups are constructing hatcheries or considering hatchery projects.

Growers have experienced considerable difficulties in obtaining adequate pl from local collectors in 1991. One observer estimates that up to 30 percent of the ponds have been stocked with imported postlarvae. Imports have been reported from Costa Rica, El Salvador, Guatemala, Panama, and the United States. Only limited price data is available, but the Panamanian pl reportedly cost about $9.00 per 1,000 pl (delivered to Tegucigalpa).[24]

VII. FARMS

The success at some farms has attracted a substantial number of new growers to the industry. The growers formed a shrimp culture growers association in 1990 to help coordinate industry promotions. Honduras in 1990 had about 20 commercial shrimp farms as well as about 60 smaller farms and artisanal producers.[25] Honduran commercial farms vary greatly in size. The farms range from large operations (up to 2,000 ha) to relatively small operations (as little as 40 ha).

The Honduran industry is dominated by the larger farms (figure 3). The success of the large operations continue to attract additional investors. The larger farms are adopting increasingly sophisticated semi-intensive methods. Available information about individual farms is as follows:

Granjas Marinas de San Bernardo (GMSB): This is the leading farm in Honduras and one of the largest and most profitable in Latin America. It was established in 1984 and is owned by a consortium of Honduran investors.[26] The company carried out a massive expansion program in 1987-88, increasing pond area from 500 to over 1,600 hectares.[27] GMSB operated 2,000 ha of ponds in 1990 and a further expansion program is in process. The World Bank's International Finance Corporation (IFC) has reportedly made a $0.5 million preferred equity investment in the project.[28] GMSB is the only farm with an operational hatchery. The existing hatchery is located in Florida, but the company is reportedly constructing one in Honduras. Considerable land remains for expansion as the Government concession is for 5,000 hectares. GMSB operates some of these ponds in a joint venture with another company, Sea Farms de Honduras.

Sea Farms de Honduras (SFH): SFH is one of the oldest Honduran farms. It was established in 1973 at Punta Raton near Choluteca.[29] It currently operates 240 ha of ponds.[30] There is little room for expansion as the private lease only covers 250 hectares.

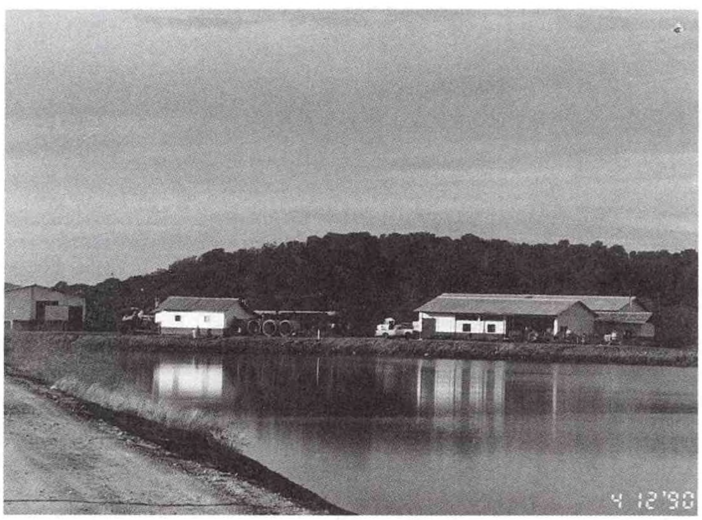


Photo 1.--Honduras. CUMAR is located on the salt flats of southern Honduras. This is the main work area, in front of the mangrove forest reserve. © *Francisco Bartlett, CUMAR*

Photo 2--*Honduras. Aerial view of Granjas Marinas San Bernardo, one of the largest shrimp farms in Latin America.* © *Roberto Chamorro, U.S. AID/FPX Shrimp Farming Project.*

Aquacultivos de Honduras: This is one of the larger Honduran farms. It was created in 1986. The Honduran Direccion General de Recursos Naturales Renovables (RENARE) reports ponds totaling about 850 ha in 1989, but unconfirmed reports suggest considerable expansion in 1990.

Cultivos Marinos (CUMAR): The original farm consisted of about 300 ha of ponds. It was rebuilt and expanded in 1988 and 1989 and now has 454 ha of ponds (17 ha of nursery ponds and 437 of growout ponds) and a new pumping station. A further expansion to 575 ha of growout ponds and 30 ha of nursery ponds was in progress as of mid-1992. The overall concession is for 800 ha, but not all of it is suitable for pond construction. Part of the concession has been set aside as a mangrove forest preserve, a program initiated by CUMAR with support from RENARE and the Forestry Department. CUMAR fully stocked its ponds in April 1990 utilizing both imported (80 percent) and locally collected (20 percent) postlarvae. The ponds were stocked at densities of from 7-10 pl per square meter. Shrimp were harvested when they reached about 16-20 grams. Feed conversion averages less than 1.8:1 well under the 2.5:1 industry average. The 1990 harvest totaled over 635 metric tons (t) of shrimp with annual yields averaging 2.6 t of shrimp per hectare. Harvests from some ponds were as high as 1.4 t per hectare per crop.[31] The company reported improved results in 1991, exporting over 900 t of shrimp. Yields per crop of up to 1.6 t per ha were achieved. The overall 1991 yield was 2.1 t per hectare because yields decline during the dry season as a result of elevated salinities.[32] The company plans to begin building a processing plant late 1992. CUMAR is also supporting the first Honduran hatchery project. A U.S. company (Seaboard Corporation) is participating in the project.

Cultivadora de Camarón (CULCAMAR): The company reported operating 380 ha of ponds in 1990. It also has a small hatchery to produce pl from imported nauplii.[33]

Acuacultura Fonseca: This farm was created in 1986. RENARE reported 300 ha of ponds in 1989, but unconfirmed reports suggest this increased to 500 ha in 1990.[34]

Many small-scale growers are also active in the industry. They use primitive methods to operate small ponds. Most of these small growers have only 2-10 ha ponds. Some of the ponds were built with manual labor.[35] Before the pl shortage, such farms were averaging yields of about 0.2-0.4 t per ha in a 3-4 month period. These small growers, however, were only able to harvest one crop annually because they lack pumps to exchange water during the dry season. As a result, the ponds are also used for salt evaporation. These smaller farms face serious operating difficulties. It is unknown how the 1988-89 *P. vannamei* shortage affected their production. Few have access to modern technology and the results of applicable research. Their small operations do not justify the hiring of costly foreign technicians and the Government offers no extension service that would assist them in making needed technical improvements. Current extension efforts backed by U.S. AID to found a private consulting group may be of special assistance to the smaller growers. (See "U.S. Participation.")

While most growers have concentrated on marine shrimp, there has also been some interest in freshwater shrimp. One company, **Aquafinca**, at La Lima near the Caribbean coast attempted to culture freshwater shrimp.[36] Aquafinca was founded by General Mills (Red Lobster) which sold it to Honduran investors in 1983.[37] The Hondurans, however, decided to close the farm in 1985. While technically successful, they concluded that the U.S. market for freshwater shrimp was not large enough to support a successful commercial operation. Another company was reportedly forced to close its freshwater shrimp farm because of high pesticide levels in the water supply.

VIII. HARVESTS

Honduran growers have been experimenting since the late 1960s but have only recently began reporting important harvests. Most observers expect continued expansion in the 1990s.

1960s: The first shrimp culture trials in Honduras were begun in 1968. The trials were conducted by Jerry Broom who built a 2 ha pilot farm along the northern (Caribbean) coast. He reportedly achieved good results using *P. occidentalis*.[38]

1970s: Following Broom's initial trial runs, **Sea Farms of Honduras** opened the first commercial farm at Choluteca along the southern (Gulf of Fonseca/Pacific) coast in 1973. Broom provided technical advice based on his pilot farm experience. The company eventually shifted to *P. vannamei* pl because of disappointing yields with *P. occidentalis*. The Sea Farms operation was one of the earliest Latin American projects.

Early 1980s: A few other growers entered the industry in the early 1980s, encouraged by the spectacular results being achieved in Ecuador and several Asian countries. For several years cultured harvests in Honduras grew relatively slowly, but after 1985 growers began to report major successes and the industry began a rapid period of expansion (figure 1).

1986-87: Several farms reported considerable progress and launched expansion programs.[39] Pond area increased to 1,300 hectares. Growers increased harvests from only 600 t in 1985 to 1,300 t in 1986 and 1,900 t in 1987 (appendix B). Honduras was hit by numerous hurricanes in 1987 and experienced a protracted rainy season. Adequate pl was available to most growers.

1988: Growers more than doubled pond area to 3,000 ha in 1988. The expansion was reflected with harvests nearly doubling to 3,420 tons (appendix B and figure 1). Growers began to report, however, a sharp decline in the availability of wild *P. vannamei* pl beginning in the second half of 1988.[40] The decline was probably associated with an extremely severe dry season with 3 particularly dry months.[41]

1989: The pl shortage continued into 1989. Growers, who were primarily dependent on wild-caught pl, had to either import expensive foreign hatchery pl at considerable cost or use available *P. stylirostris* postlarvae. (See "Yields/Production Costs.") The pl shortage continued into 1989 and significantly impaired harvests. Growers reported a 1989 harvest of only 3,200 t, despite a continued expansion of pond area (appendix B and figure 1).

1990: Growers reported a much improved availability of pl, especially *P. vannamei* in 1990. As a result, most farms achieved substantially improved harvests. Annual data are not yet available, but available estimates based on export data suggest that about 5,500 t was harvested in 1990 (appendix B and figure 1).[42]

1991: Projections for 1990 are not available, but most observers are predicting a substantial harvest increase (appendix B and figure 1). Projections based on initial producer plans suggest a harvest of about 6,800 tons. Honduran growers are reporting relatively low water temperatures (25°C) and high salinities. These factors may be affecting pl availability. Preliminary reports of poor pl availability[43], however, are not encouraging and end year results are highly conjectural.

The industry's impressive growth has enabled the Honduran shrimp culture industry to emerge as one of the most important in Latin America. Harvests in 1989 were the fourth most important in the region, exceeded only by Ecuador, Colombia, and Mexico, all countries with much larger areas (appendix E). It is likely that these countries will continue to exceed Honduran harvests, given the relatively small area available to Honduran growers. The industry may report impressive increases in the 1990s, however, if growers continue improving methods and if farms can be successfully opened along the Caribbean coast.

IX. YIELDS/PRODUCTION COSTS

Honduran growers generally use semi-intensive methods. One estimate suggests that nearly 95 percent of existing commercial farms employ semi-intensive methods.[44] These are primarily modern, well-designed operations (appendices C and D), operating 200 or more ha of ponds.[45] Only about 5 percent used extensive methods. The extensive farms are generally small undertakings operated by individual growers or family groups.

The species of shrimp stocked in the ponds is one factor which significantly affects yields. Most growers want *P. vannamei* postlarvae. The 1988-89 pl shortage, however, forced many growers to use *P. stylirostris*. As a result they had to adjust their growout operations. Many reportedly stocked their ponds with a mixture of approximately 80 percent *P. stylirostris* and 20 percent *P. vannamei*, which greatly reduced yields per hectare. Several growers, however, reportedly developed considerable skill in adapting growout strategy to *P. stylirostris*. The most effective step was apparently to use better quality feed (higher protein content) than normally required for *P. vannamei*.[46] Some observers also point out that larger *P. stylirostris* individuals can be harvested.[47] As the larger shrimp are more valuable, this partially compensated for the lower yields.

Honduran growers appear to be making progress in improving yields. One report indicated that growers achieved yields of about 0.45 t per ha per harvest in 1990, a solid increase over the 0.35 t per harvest in 1989. Most growers report about two harvests per year, but the more efficient growers are averaging 2.5 harvests annually.[48] Overall growers in 1990 averaged yields of about 0.8 t per ha annually.[49]

Honduran growers are currently studying various growout strategies in an effort to improve yields. The large commercial farms reported annual yields of up to 1.6 t per ha using *P. vannamei*, but only 1.0 t using *P. stylirostris*.[50] Some local observers believe that the principal problems growers have experienced in using *P. stylirostris* are lack of experience in handling the species and poor quality local feeds. One report suggests that *P. stylirostris* has to be stocked at low density.[51] This is particularly important if high-quality (high protein) feed is not available.[52] Other experts mention the importance of high quality feed. Industry sources say that Panamanian shrimp growers using *P. stylirostris* have reported annual yields of up to 1.4 t per hectare. Two Honduran farms are using Panamanian methods and importing Panamanian feeds[53] with a 40 percent protein content as opposed to the lower quality feed (25 percent protein content) available from local feed mills. The growers using the Panamanian feed report that in ponds stocked with over 80 percent *P. stylirostris* pl, initial results from their first crop indicated annual yields of over 1.5 t per hectare.[54] Many in the industry remain skeptical, however, that *P. stylirostris* culture can ever be as profitable as operations using *P. vannamei*.

Various estimates exist on production costs. One rather imprecise estimate suggested production costs of about $4.00 per kilogram. This figure was based on the use of *P. vannamei*. It is unclear if it was the fully loaded cost, including both operating costs and underlying mortgages. Cost data compiled by another observer suggests 1990 production costs (FOB) of between $3.10 (operating costs) and $4.40 (fully loaded costs) per kg of tails.[55] These estimates are based on the use of wild, locally collected pl seedstock. Growers in 1991 have to import substantial quantities of pl and as a result, 1991 costs may be substantially higher.

Pond construction costs estimates vary substantially from source to source. One knowledgeable source suggests that construction averages about $6,000 per hectare.[56] Costs at some sights, however can be substantially higher. Construction costs of up to $10,000 per ha have been reported.

X. PROCESSING

Most Honduran shrimp processing companies are located in the north, along the Caribbean coast or in the Bay Islands, to serve the long-established capture fishery. These plants have more than sufficient capacity to process the shrimp landed by fishermen, even during the peak fishing season. Their location, however, makes them of little use to the rapidly expanding pond culture operations in the south.

The southern coast processing situation has changed radically in the past year.

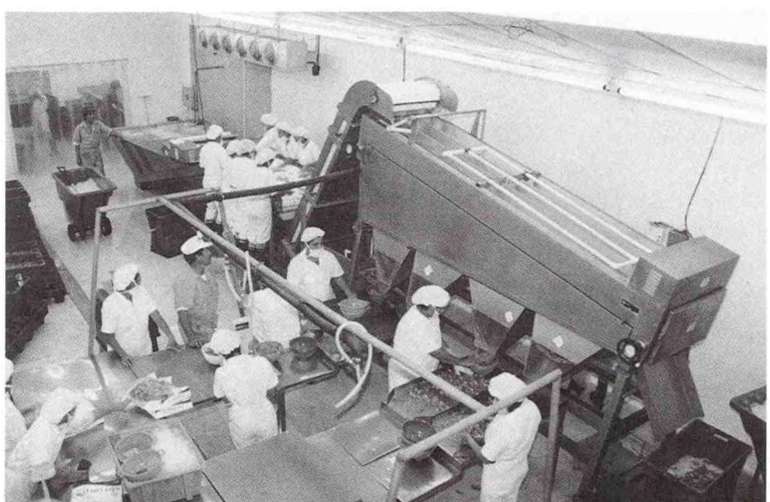


Photo 3.--*Honduras. The rapidly expanding pond harvest is creating a modern processing industry with high quality standards. © Roberto Chamorro, U.S. AID/FPX Shrimp Farming Project.*

1989: As late as 1989, only two processing plants served the needs of shrimp producers along the southern (Gulf of Fonseca) coast. The **Hondu-Fish** plant was located in Tegucigalpa, about 225 km from the southern coast. The plant was a small, relatively outdated plant with a gross production capacity of only about 4.5 t per day. The location made it expensive to operate and the owners decided to relocate to the Choluteca area and expand the capacity to 13.6 t daily. The **Empacadora de Productos Aquaticos de San Lorenzo** (EPASL) plant was located close to the coast. It was owned by the same group operating GMSB, SFH, and Aquacultivos. It had a daily processing capacity of about 28 tons. The plant was reportedly modernized in 1989 and

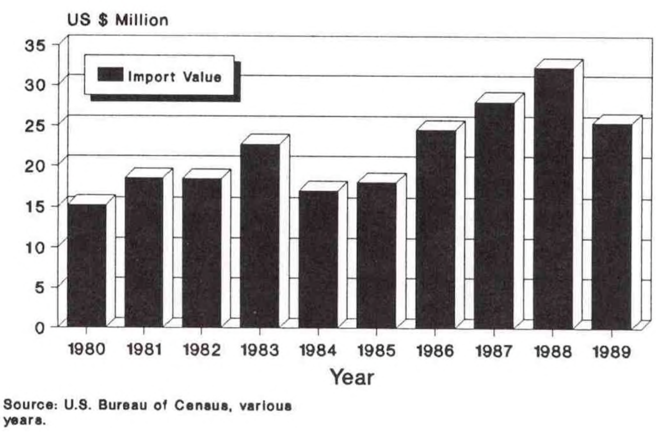


Figure 4.--Honduras. U.S. shrimp imports from Honduras increased during the 1980s and most observers expect continued increases during the 1990s.

a water treatment plant was installed because of the severe local water supply problem.[57]

1991: Southern growers now have much improved access to processing plants. The **Hondu-Fish** plant has closed. Two plants currently operate in San Lorenzo, the old **EPSAL** plant and a small new plant, **Empacadora San Lorenzo** which can process about 5 t per day. Two plants have also opened at Choluteca. **Santa Ines** can process about 10 t per day. **Choluteca Industrias Marinas Valle** also has opened, but its capacity is not available.

Given the industry's rapid expansion, the existing plants will not be able to process future pond harvests. Independent growers may find it especially difficult to process their harvests. The owners of some of these processing plants operate ponds. These processing plants will thus give priority to affiliated growers, leaving little capacity available for independent growers. Unconfirmed reports suggest that two additional groups are seeking funds to finance additional plants.

XI. TRANSPORTATION

Companies along the northern coast have long-established transportation and market patterns. The catch is shipped directly, either to the Bay Islands or Omoa (near Puerto Cortés), for processing. Four packers have their own ships to carry shrimp and other seafood in refrigerated containers to Miami or Tampa. This service is also available to other packers. Shipments are made about once every 2 weeks during the peak fishing season. Some packers air freight their product, either from Roatan (Bay Islands) or from San Pedro Sula on the mainland (Map). Some companies complain that air freight shippers are undependable and some seafood companies have been unable to meet their obligations. Other companies complain that delays have impaired the quality of the product. Several air charter companies are reportedly considering the Honduran market, but have not yet made commitments due to the lack of cargo back from the United States. Several tons of shrimp were air freighted to the United States in 1990, but detailed statistics are not available.

Shrimp growers along the southern (Gulf of Fonseca) coast face several transport difficulties, but the most serious is the poor road network. Except for the Tegucigalpa-Choluteca highway, which is being reconstructed, few roads are paved. Farms can only be accessed by heavy duty or four wheel drive vehicles. Since there were no processing plants adjacent to the areas where the farms are located, the harvest has to be trucked 25-55 km to San Lorenzo or 225 km to Tegucigalpa. This affected the quality of the product, especially the shrimp shipped to Tegucigalpa. The processing situation is now much improved, but expanding harvests require additional new processing plants.

Once processed, the shrimp is placed in refrigerated containers for transportation to the northern port of Puerto Cortés, about 480 km from Tegucigalpa (Map). Container availability is reportedly adequate. The main sea carriers to the United States are CCT, SeaLand, Seaboard, Nexos Line, Maersk, and Concorde line.[58]

XII. EXPORTS

Shrimp is currently one of the leading Honduran export commodities. In 1990, it was the country's third most important export, surpassed in importance only by bananas and coffee. Some observers believe that due to the success of the country's shrimp growers, it will eventually become the major export commodity. Some discrepancies exist between various estimates of Honduran exports (appendices F, G, and H).[59] Most of Honduras' shrimp exports are shipped to the United States. As a result, U.S. import data may be a fairly accurate indicator of industry trends. In the early 1980s, shipments to the United States varied from $15 million in 1980 to $23 million in 1983 (figure 4). Expanding cultured harvests have enabled exporters to increase shipments. U.S. imports reached a record high of $32 million in 1988, more than half of which was cultured (appendices G and H).[60] Exports declined substantially in 1989, confirming the difficulties growers encountered with pl supplies and the resulting lower harvests. Shipments to the United States were only $25 million in 1989 (appendix H). Exporters to the United States in 1990 recovered to record 1988 quantities (4,100 t), but lower prices meant that the value ($28 million) fell short of the 1988 record.

The Honduran Government has implemented policies which adversely affect exporters. The Government introduced an **export duty** in 1990. The law was modified in late 1990 to exempt non-traditional exporters. Thus shrimp growers are no longer affected. Traditional exporters, such as shrimp fishermen, however, are affected by the law which requires a payment of 9 percent on the FOB value of the shipment. Both growers and fishermen are affected by the **foreign currency controls** administered by the Central Bank (BCH). The Foreign Exchange Repatriation Law (1990) requires Honduran exporters to repatriate all of their export earnings through the domestic commercial banking system. The proceeds are then divided through a complicated system between the BCH, the commercial bank of deposit, and the exporter. The system in essence means that the conversion mechanism is a substantial tax on export earnings.[61] In addition, the rigidity of the system and the increase in costs caused by delay and red tape actually impair exports. The regulations entail some risk for exporters as even inadvertent violation can result in very substantial fines.[62]

The Government is encouraging new processors and exporters to enter the industry. New companies have the advantage that small shipments do not have to be handled through the BCH which means that they are exempt from the foreign currency controls levied on larger exporters. Small shipments of up to $5,000 can now be exported duty free. Several small companies are reportedly interested in the growing air shipment trade. (See "Transportation.")

XIII. HATCHERIES

Unlike most other Latin American countries with important shrimp culture industries, Honduran growers did not initiate major hatchery projects in the 1980s. Growers generally believed that wild pl stocks were adequate. The failure to build hatcheries is somewhat surprising as Honduras is emerging as one of the more important Latin American producers of cultured shrimp. Growers are now recognizing the importance of securing adequate pl supplies and several have initiated or are considering hatchery projects.[63] The 1988-89 and 1991 pl shortages have reportedly convinced many growers that hatcheries are essential to assure the availability of adequate quantities of postlarvae.

Sea Farms built a hatchery in the late 1970s, but it has been closed since 1981.

Granjas Marinas de San Bernardo has a hatchery that recently began operations at Florida's Summerland Key, using at least some broodstock from its Honduran farm. The company is now building a hatchery in Honduras.

CULCAMAR currently operates the only hatchery in Honduras. The company produces pl from imported nauplii.[64]

Others: A consortium of Honduran growers is reportedly considering a hatchery.

The absence of local hatcheries leaves growers dependent on the vagaries of wild shrimp stocks or costly imports for their postlarval seedstock. The industry's further expansion will be dependent on the availability of sufficient supplies of suitable seedstock. The lack of hatchery-produced pl is one factor currently restricting the industry's growth. Future harvest increases will be dependent on either the adoption of Panamanian *P. stylirostris* handling methods or the development of local hatcheries. Continued improvement in *P. stylirostris* yields can probably be expected, but most observers feel continued rapid expansion of the industry will be impossible without investment in hatcheries and other infrastructure. Even if wild-caught *P. vannamei* pl were abundant, the rapidly expanding number of ponds means that growers would have difficulty meeting their expanding seedstock requirements.

XIV. LEGAL FRAMEWORK

Honduran law has entailed some complications for growers. The national Constitution formerly reserved land ownership within 40 km of the coast to Honduran nationals. This severely limited foreign ownership of land appropriate for aquaculture and thus adversely affected foreign participation in the industry. In practice, however, this limitation was often circumvented by a variety of legal arrangements, a trusteeship by local banks being the most common. The Honduran Government modified the law restricting coastal land ownership in 1990 (Decree number 9090, August 1990). Preliminary reports suggest that projects using costal land can now be fully owned by foreign investors if the production is exported, or if the enterprise is a tourist facility.[65]

Growers must obtain Government concessions to build and operate shrimp farms. Several agencies are involved in the authorization process.[66] The Ministry of Culture and Tourism determines a concession's size and issues a legal opinion concerning the propriety of the concession. RENARE approves development plans and assures that the local environment is not adversely affected. A variety of other agencies can affect the concession process. After the Ministry of Culture and Tourism has issued a favorable legal opinion, the Attorney General's Office is then authorized to issue a concession lease contract. Concession leases for shrimp farms are granted for 20-year periods. Investors complain that such a period is too short, citing investments averaging $6,000 per ha to build a farm.[67] Many banks are reportedly uncertain about approving loans given this constraint.

XV. CREDIT

Honduran growers have experienced considerable difficulty in obtaining investment credits. Honduran banks are generally conservative institutions, hesitant to invest in unproven new industries. The banks also lack sufficient expertise to assess the technical feasibility of shrimp culture projects. Collateral has proven a particularly difficult problem. Since concession rights are retained by the Government, they cannot be offered as collateral when applying for loans. Furthermore, as shrimp is a highly perishable product, inventories cannot be offered to secure working capital credit lines. The limited access to credit is aggravated by the current liquidity crunch in the banking system resulting from the Central Bank's high reserve requirement (35 percent) to help finance the Government's large budget deficits.[68]

Both domestic and foreign investors have been concerned about various Honduran laws. Some of these restrictions have been modified, but the complications and temporary nature of such laws worry investors. The land ownership regulations in place until 1990 limited foreign investment. (See "Legal Framework.") Export duties and foreign exchange controls concern all potential investors. Foreign investors in particular object to the restrictions on currency convertibility, especially the long delays in remitting dividends, interest, and payments on principal.[69]

XVI. U.S. PARTICIPATION

Various U.S. groups have been active in the Honduran shrimp culture industry. U.S. investment was limited, however, by Honduran law which restricts foreign purchases of coastal land. As mentioned above ("Legal Framework"), land could be held in trust for foreigners, but the overall impact of the law was to discourage direct U.S. equity participation. The recent modification of the law could mean expanded U.S. interest in Honduran investment.

U.S. investors play a role in some farms, but few details are available. Important U.S. companies such as Red Lobster have been involved in the industry. In addition, much of the technical support, especially for the increasingly sophisticated semi-intensive operations, has come from U.S. technicians and consulting companies. Honduras' largest hatchery is located in Florida.

The U.S. Government is also participating in the industry's development. The U.S. Agency for International Development (AID) has established a program to promote non-traditional exports and about $7 million in loans have been made to companies farming shrimp. Given the difficulty growers have had in obtaining commercial credits, the AID program is playing an important role in the industry's development. AID is attempting to encourage investment in local hatcheries, feed mills, and processing plants in an effort to ensure a more balanced development of the Honduran shrimp culture industry. The AID funds were provided to commercial banks through the Honduran Central Bank.[70] In addition, AID has contracted two technical advisors to provide technical and financial advice to growers. AID hopes that this effort will eventually become a self-supporting consulting group which can service the needs of both established companies and small-scale growers.[71] AID is also encouraging the development of a permanent credit mechanism supported by an exporter's federation. No hatchery or feed plant projects, however, have yet been approved for funding.

The U.S. Embassy in Tegucigalpa reports that the expanding shrimp culture industry is creating a variety of opportunities for U.S. companies. The Embassy reports that the Federation de Asociados de Productores y Exportadores Agricolas y Agroindustriales de Honduras (FPX) has set priorities for the industry, primarily ice and packing plants, feeds, hatcheries, and related industries.[72]

Honduran newspapers reported in 1990 that a U.S. company (Energy Resources) was planning a project to provide electrical energy created by burning wastes to a Honduran shrimp farm.[73] Current information on the proposed project is unavailable. The U.S. Embassy points out that such an operation appears to conflict with a Central American regional agreement to ban the importation of residual waste materials for any purpose. The Embassy also reports that the ban is supported by the AID-financed environmental protection program.[74] Honduran Government policies are currently to postpone Caribbean coast shrimp culture projects and, as a result, the company's application is reportedly on hold.

XVII. GOVERNMENT ROLE

The previous Honduran Government assisted shrimp growers as part of its overall development efforts. Several legal vehicles were created to facilitate development of non-traditional products. Shrimp growers were eligible for these programs, including the Non-traditional Export Promotion Law (NEPL), the CEFEX Program, and the opening of a one-stop export processing center.

NEPL: The export promotion program offered benefits to exporters of non-traditional products, which include farmed shrimp. Exporters received certificates for 15 percent of the value of their exports which were applied against taxes. Other benefits included exemption from import duties on heavy equipment, 5-year income-tax exemptions, and special low-interest government loans.

CEFEX: This program offered certificates on the Honduran currency, the lempira, for up to 15 percent of the total export revenue, depending on the local value added to a product. These certificates were freely traded in the local market and were used to pay taxes.

Export Processing Center: The center facilitated the export process by offering access to all regulatory agencies in one location, saving the exporter considerable time and money.

The current Callejas Government which assumed office in January 1990 has taken a decidedly free market approach to economic policy. This has included the canceling or scaling back of various Government support programs. The CEFEX program, for example, was reportedly terminated in March 1990. Exporters have been assisted, however, by a major currency devaluation.[75] The current exchange rate now more accurately reflects the value of the lempira, thus substantially increasing the earnings of many shrimp companies. The Government introduced a temporary tax on exports (9-14 percent) to limit wind-fall profits, but eliminated it during October 1990.[76]

Despite the above efforts to promote exports, the Government's overall economic policies have probably acted to discourage investment in new industries like shrimp culture. Restrictions on land ownership, currency conversion, and repatriation of profits as well as export duties force potential investors to critically evaluate potential Honduran investments. (See "Exports," "Legal Framework," and "Credit" for details.) While some of these regulations have been modified, constant changes in these policies is a further factor of concern to investors.

XVIII. SYMPOSIUM

The Honduran Federation of Agricultural Producers and Exporters (FPX) and the Honduran National Aquaculture Association (ANDAH) are organizing the "Central American Symposium on Shrimp Farming." The Symposium will be held in Tegucigalpa, April 24-26, 1991. The program will include a presentation by each Central American country on the status of the shrimp culture industry, conferences on a variety of technical and administrative topics, meetings to introduce new products and services, and working groups to discuss technical themes of interest to Central American producers. U.S. AID and the Organization for Latin American Fisheries Development (OLDEPESCA) are sponsoring the symposium.

XIX. ECONOMIC IMPACT

The success of Honduran growers is creating a major new industry for the country. Seafood has for years been a principal export commodity, but the limited wild stocks of shrimp and lobster restricted the industry's expansion. The current increases in cultured harvests are making possible a major expansion of both earnings and export revenue.

The developing shrimp culture industry could have a major impact on the Honduran economy. The increased production now contemplated could eventually make it the country's most important export earner. One 1988 study suggested that the shrimp culture industry provided employment for 2,500 people and that development of the potential sites along the Gulf of Fonseca could eventually create jobs for 40,000 Hondurans.[77] Development of Caribbean sites would expand that amount even further. As many as 250 companies may eventually enter the industry. Shrimp production in the 1990s could well exceed $100 million and the overall income of farms and support industry would be substantially more.[78] The employment numbers and export data cited in the "Export" section may not seem massive to U.S. analysts, but they represent significant activity in the small Honduran economy. The country's Gross Domestic Product was only $4.9 billion in 1989. The emergence of an important shrimp culture industry could have a major impact on such a small economy. The industry's development is already having a massive impact along the southern coastal area where it is currently centered. The level of activity projected for the 1990s in this report could have a pronounced impact on the country's overall economy.

Not all assessments are as optimistic. Environmentalists are concerned about the impact of cutling mangroves and developing estuarine areas for pond construction. Artisanal fisherman complain that their operations are being impaired.[79]

This report was originally prepared by Dennis Weidner and published as IFR-91/21 on March 29, 1991. Minor revisions were made subsequently to update some of the individual farm entries.

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______. Director of Agricultural Services, General Mills, personal communications, September 22, 1983.

ENDNOTES

SECTION I (Shrimp Fishery)

1. *El Agricultor*, January 8, 1990.

SECTION II (Climate and Geography)

2. Depending on the year, the dry season can begin any time between November and January.

SECTION III (Area)

3. U.S. Embassy, Tegucigalpa, July 20, 1989. Roberto Chamorro, financial advisor for a U.S. AID shrimp farm project, confirms the Embassy estimate. Chamorro, personal communications, January 28, 1991.

4. INFOPESCA, *Noticias Comerciales*, May 8, 1988.

5. RENARE as cited by the U.S. Embassy, Tegucigalpa, July 20, 1989.

6. Chamorro, *World Shrimp Farming*, 1990.

7. Chamorro, personal communications, January 28, 1991, *op. cit.*

SECTION IV (Condition)

8. The area has especially favorable soil conditions. Enrique Ramirez G., Agropecuaticos, item 12.6.4, *Aquaculture Digest* June 1987.

9. *Medio Ambiente Latinoamericano, No. 4/88.*

10. At least one grower (CUMAR) has instituted a mangrove planting program in their canal system and has mangroves 2 m high. The company also has a 23-ha nature reserve. Jack Crockett, General Manager, Cultivos Marinos, July 6, 1992.

11. U.S. Embassy, Tegucigalpa, July 20, 1989.

12. Chamorro, personal communications, January 28, 1991, *op. cit.*

13. Bill McGrath, Shrimp Culture Inc., personal communications, January 17, 1991.

SECTION V (Species)

14. Cornelius Mock reported that in his conversations with Honduran growers, they reported *P. occidentalis* takes too long to grow and that *P. schmitti* resulted in poor production. Growers reported low survival rates with *P. stylirostris*. Cornelius Mock, "Trip Report: Sea Farms de Honduras," April 11-18, 1980 p.20. Scattered reports suggest that some of these species may be cultured. Broom reported, for example, success with *P. occidentalis* in the 1960s. (See "Harvests.") Most growers, however, are convinced that *P. vannamei* is the species best suited for Honduran conditions.

15. For details on the performance of *P. stylirostris* see "Yields/Production Costs."

16. Chamorro, *World Shrimp Farming*, *op. cit.*

17. Del McCluskey, AID Officer, U.S. Embassy, Tegucigalpa, personal communications, February 4, 1991.

18. Chamorro, personal communications, January 28, 1991, *op. cit.*

19. Pl are normally scarce during the beginning of the year, but usually small quantities can be collected. Artisanal collectors reported in January and February that *P. vannamei* and *P. stylirostris* pl were almost totally absent. Roberto Chamorro, personal communications, February 19, 1991.

SECTION VI (Postlarval Supplies)

20. *Ibid.*

21. Mock, *op. cit.*, p.3.

22. Durwood Dugger, personal communications, April 30, 1991.

23. Maugle, *op. cit.*

24. Chamorro, personal communications, March 26, 1991.

SECTION VII (Farms)

25. A RENARE official suggested that there were about 15 commercial and 50 smaller farms in 1989. Sixto Evelio Amador, Jefe Regional RENARE Sur, unpublished report, March 28, 1989. Chamorro suggests that by 1990 there were 20 commercial farms and 60 small farms. Chamorro, personal communications, January 28, 1991, *op. cit.* For details on the major farms see appendices C and D.

26. U.S. Embassy, Tegucigalpa, February 19, 1986.

27. Chamorro reports that the area of ponds expanded to 2,000 ha in 1990. Chamorro, USAID/FPX, item 16.3.25, *World Shrimp Farming*, March 1991, p.21.

28. U.S. Embassy, Tegucigalpa, February 12 and April 10, 1986. The World Bank still retains its equity position in GMSB. World Bank, personal communications, February 1, 1991.

29. A survey of the Sea Farms operation was prepared in 1980 by Cornelius Mock, "Trip Report: Sea Farms de Honduras," April 11-18, 1980.

30. Ralph Parkman, personal communications, May 14, 1990.

31. Jack Crockett, Cultivos Marinos, personal communications, January 24, 1991.

32. Crokett, *op. cit.* July 6, 1992.

33. Antonio Tavel, CULCAMAR General Manager, personal communications, January 18, 1991.

34. Estimates vary as to the area of ponds. One observer estimates Acuacultura Fonseca had 350 ha of ponds in 1990. Chamorro reports that the company has 500 ha of ponds. Chamorro, item 16.3.25, World Shrimp Farming, *op. cit.*

35. A complete list is available from RENARE. Amador, *op. cit.*

36. For details on Aquafinca see Ron Wulff, "General Mills' Experience in Fresh-Water Shrimp Farming in Latin America," *Proceedings of the Thirty Fourth Annual Gulf and Caribbean Fisheries Institute* (Mayaguez, Puerto Rico, November 1981), August 1982, pp.88-89.

37. Wulff, Director of Agricultural Services, General Mills, personal communications, September 22, 1983.

SECTION VIII (Harvests)

38. Ramirez, *op. cit.*

39. Paul Maugle, shrimp farming consultant, item 13.3.35, *Aquaculture Digest*, March 1988, p.19.

40. INFOPESCA

41. Chamorro, personal communications, February 19, 1991, *op. cit.*

42. Obtaining 1990 harvest data has proven particularly difficult in 1990. Much of the harvest estimates are based on export data. Honduran export data, however, has been complicated by a new law which permits small export shipments to be made duty free. This has encouraged several small companies to process shrimp and export by air. The entry of these new companies has greatly complicated data collection.

43. For details on the 1991 pl situation see "Postlarval Supplies."

SECTION IX (Yields/Production Costs)

44. Robert Rosenberry, "Honduras," *World Shrimp Farming*, 1990.

45. See "Farms" for available details on individual companies.

46. Rosenberry reports that such feed had to be imported and while the import system is complicated, farms that obtained the imported feeds reported sharply improved results with *P. stylirostris*. Rosenberry, *op. cit.*

47. Robin Rackowe, personal communications, July 18, 1990.

48. McCluskey, *op. cit.*

49. Rosenberry, *op. cit.*

50. Other observers estimate even lower *P. stylirostris* yields. Chamorro estimates annual yields at about 0.7 t per hectare. Chamorro, *World Shrimp Farming*, *op. cit.* Rosenberry reports annual yields of only about 0.4 t per ha, but says that farms using high quality feeds achieved yields of nearly 0.9 t per hectare. Rosenberry, *op. cit.*

51. 1-2 pl per square meter. INFOPESCA, *Noticias Comerciales*, May 8, 1988.

52. Chamorro, personal communications, January 28, 1991, *op. cit.*

53. Farms report considerable difficulty in obtaining import authorizations, primarily due to foreign exchange controls. At least some of the feed imported from Panama was produced in the United States.

54. Chamorro, personal communications, January 24, 1990, *op. cit.*.

55. Calculated for 41-50 count shrimp. Chamorro, personal communications, March 26, 1991.

56. *Ibid.*

SECTION X (Processing)

57. U.S. Embassy, Tegucigalpa, "Industry Sector Analysis: The Honduran Shrimp and Fish Industry," July 20,

1989, p.5.

SECTION XI (Transportation)

58. *Ibid*, p.5-6.

SECTION XII (Exports)

59. Tracking trade data in Honduras and several other Latin American countries is complicated by smuggling to and from neighboring countries to avoid a variety of tax and exchange control laws. (See Exports.") NMFS has received reports of such shipments from El Salvador and Nicaragua, but it is impossible to quantify such movements. They are also highly variable by year depending on changes of regulations and enforcement. See for example, U.S. Embassy, Tegucigalpa, November 8, 1983. Unconfirmed reports suggest that in Honduras this is primarily associated with trawler-caught shrimp. One source insists that the Honduran cultured harvest is mostly reported accurately to the Government and very little is involved in illicit shipments.

60. Chamorro reports that by 1989, shrimp farmers were providing more than 60 percent of export shipments, even though pond harvests declined in that year (appendix G).

61. The U.S. Embassy reports that certain groups, such as the melon and shrimp growers, have been able to negotiate special arrangements with the BCH. U.S. Embassy, Tegucigalpa, January 18, 1991.

62. U.S. Embassy, Tegucigalpa, January 18, 1991.

SECTION XIII (Hatcheries)

63. Chamorro, *World Shrimp Farming, op. cit.* and McCluskey, *op. cit.*

64. Tavel, *op. cit.*

SECTION XIV (Legal Framework)

65. Chamorro, personal communications, January 28 and February 19, 1991, *op. cit.*

66. The following assessment of the concession process was prepared by the U.S. Embassy, Tegucigalpa, July 20, 1989.

67. Some sources suggest even higher construction costs of from $7,000-$10,000 per hectare.

SECTION XV (Credit)

68. U.S. Embassy, Tegucigalpa, July 20, 1989, *op. cit.*.

69. U.S. Embassy, Tegucigalpa, March 18, 1991.

SECTION XVI (U.S. Participation)

70. The funds made available by AID totaled $14 million. AID did not assign a specific priority to shrimp farming. The fact that about half of the funds were allocated to shrimp culture projects was an economic decision made by Honduran investors and commercial banks. U.S. Embassy, Tegucigalpa, July 20, 1989 and McCluskey, *op. cit.*

71. Chamorro, personal communications, February 19, 1991, *op. cit.*

72. For details see NMFS, "Honduran Shrimp Culture Opportunities," IFR-90/50, September 27, 1990.

73. Newspapers reported that the plan involved the burning of toxic waste, but this was reportedly not the case. Repeated attempts to contact the companies involved have been unsuccesful.

74. U.S. Embassy, Tegucigalpa, October 5, 1990.

SECTION XVII (Government Support)

75. Until March 1990, Honduras adhered to a fixed official rate of exchange of 2 lempiras to the dollar first introduced in 1918. However, with inflation surging and productivity lagging behind its major competitors, this source of national pride contributed to economic instability. During 1989, the black market value of the lempira fell to less than half its official value. In March 1990, the Central Bank devalued the lempira by 100 percent, establishing a so-called customs valuation rate of 4 lempiras per dollar. The official two-for-one rate was retained only for foreign debt repayments. A second minor devaluation followed in May. Nevertheless, these devaluations failed to keep pace with the lempira's rapid decline on the black market. Finally, in early October 1990, the Central Back announced a "unified" rate of 5.5 per dollar. The Government has committed itself to regular adjustments to minimize the gap between the unified rate and the black market.

76. McGrath, *op. cit.*

SECTION XIX (Economic Impact)

77. Maugle, *op. cit.*

78. Such estimates project a possible future outcome if growers were supported by an expansive assistance program and rapidly improve growout operations. One observer suggests a high-range impact by 1993 of shrimp harvests totaling $135 million and up to $170 million worth of income could be generated by farmers and support industry. Maugle, *op. cit.* While such estimates now seem optimistic by 1993, it seems likely that growers will report very substantial increases in harvests and earnings during the 1990s.

79. Sandy Tolan "All Things Considered" National Public Radio, April 18, 1992.

APPENDICES

Appendix A.--Honduras. Addresses

Agro Industrias Hondufarm's
Antiguo Edificio Bodega San José
Frente Discoteque Badminton
Choluteca, Honduras
Telephone: 504-82-2227
FAX: 504-82-2444

Aquacultivo De Honduras, S.A.
430 Hectares
Apdo. Postal 213/811
Tegucigalpa, Honduras
Telephone: 504-32-6645
FAX: 504-32-9443

Agromarina Chismuyo, S.A.
150 Hectares
Honduras
Telephone: 504-32-3242

Aquacultura Fonseca, S.A.
475 Hectares
Apdo. Postal 255
Choluteca, Honduras
Telephone: 504-82-2037
FAX: 504-82-2655

Aquacultivo De Honduras, S.A.
430 Hectares
Apdo. Postal 213/811
Tegucigalpa, Honduras
Telephone: 504-32-6645
FAX: 504-32-9443

Bo. Concepción, Atras Sucursal Banco Atlantida
40 Hectares Independent Producer
Casa #948
Comayaguela, D.C., Honduras
Telephone: 504-37-6388
FAX: 504-82-3848

Camarones y Derivados
120 Hectares
La Ceiba Atlántida, Honduras
Telephone: 504-42-0269
FAX: 504-42-1161

CADELPA
500 Hectares
2Kms. Carretera Marcovia, La Granja
Choluteca, Honduras
Telephone: 504-82-2131
FAX: 504-82-3292

CULMASA
40 Hectares
Bo. el Centro, Ave. Soto,
Choluteca, Honduras
Telephone: 504-82-0070
FAX: 504-82-2348

Criaderos Especiales Marinos
40 Hectares
Col. Las Acácias, Bloque #7, Casa #6
Choluteca, Honduras
Telephone: 504-82-0986
FAX: 504-82-2848

Cultivadora De Camaron, S.A.
360 Hectares, Apdo. Postal 1792
Tegucigalpa, D.C. Honduras
Telephone: 504-32-0778
FAX: 504-32-0833

Cultivos Marinos, S.A.
437 Hectares, Apdo. Postal 236
Choluteca, Honduras
Telephone: 504-82-2111
FAX: 504-82-0930

Empacadora De Productos Aguaticos San Lorenzo
San Lorenzo, Valle, Honduras
Telephone: 504-81-2339
FAX: 504-81-2338

Empacadora De Camarones Santa Ines
2da. Ave., 11 Calle,
Comayaguela, D.C., Honduras
Telephone: 504-37-6858
FAX: 504-37-6857

Empacadora Pacific Sea Products
Bo. el Mongollano,
San Lorenzo, Valle, Honduras
Telephone: 504-81-2356
FAX: 504-81-2398

Granja Marino San Bernardo
PO Box 184
Choluteca
Honduras
Telephone: (504) 82-0168/0187

Granjas Marinas San Bernardo
1500 Hectares

Apdo. Postal 184
Choluteca, Honduras
Telephone: 504-82-0168
FAX: 504-82-0917

Honduras Camaron
40 Hectares
Apdo. Postal 22
Choluteca, Honduras
Telephone: 504-82-2338

Honduespecies
136 Hectares
Apdo. Postal 106
Choluteca, Honduras
Telephone: 504-82-2635
FAX: 504-82-2645

Independent Producer
San Lorenzo, Valle, Honduras
Telephone: 504-81-2244
FAX: 504-81-2127

Independent Producer
20 Hectares
Monjaras, Choluteca, Honduras
FAX: 504-82-3848

Independent Producer
20 Hectares,
Bo. Victoria
San Lorenzo, Valle, Honduras
Telephone: 504-81-2174

Inversiones Maritimas
Bo. la Esperanza
Media Cuadra al Norte
De Viveros Tropicales del Sur
Choluteca
Honduras
Telephone: 504-82-2725
FAX: 504-82-2726

Portillo De La Bloria
145 Hectares
Apdo. Postal 40
San Lorenzo, Valle, Honduras
Telephone: 504-81-2207
FAX: 504-38-0274

Sea Farms De Honduras, S.A.
250 Hectares
Apdo. Postal 33
Choluteca, Honduras
Telephone: 504-82-0187
FAX: 504-82-3500

Seafarm de Honduras
PO Box 33
Choluteca
Honduras
Telephone: (504) 82-0168/0187

Appendix B.--Honduras. Penaeid shrimp trawl catch and pond harvest, 1980-95

Year	Production			Pond
	Trawl	Pond	Total	Area*
	1,000 Metric tons**			1,000 Hectares
1980	2.6	Negl	2.6	NA
1981	2.2	0.1	2.3	NA
1982	1.9	0.2	2.1	NA
1983	3.2	0.3	3.5	NA
1984	2.0	0.5	2.5	0.3
1985	2.1	0.6	2.7	NA
1986	1.9	1.3	3.2	0.7
1987	2.7	1.9	4.6	1.3
1988	2.3#	3.4E##	5.7***	3.0
1989	1.9	3.2E	5.1E	4.2
1990	NA	5.5E	NA	6.0
1991	NA	6.8P	NA	NA
1994	NA	9.0P♦	NA	NA
1995	NA	10.0P♦♦	NA	15.0

U.S. Embassy, Tegucigalpa, February 13, 1990.
Some sources have reported a substantially lower pond harvest of only 2,400 tons.
* Operational ponds
**Liveweight
***Available 1988 data from FAO (4,700 t total production) does not fully confirm the sharp increase in cultured shrimp harvests reported by the industry.
♦ INFOPESCA projects 9,000-11,000 tons.
♦♦ Fairly conservative projection. Harvests could be substantially higher if the projected area of ponds are built and farmers resolve pl supply problems.
F - FAO estimate
E - Estimated Chamorro, FPX
P - Projection
Sources: FAO. Yearbook of Fishery Statistics, various years (1980-88 totals); NMFS/NOAA IFR/88-38 "Latin American Shrimp Culture Industry, 1986-1990" (pond culture totals, 1980-85); U.S Embassy, Tegucigalpa, July 20, 1989 (pond culture totals, 1986-88); Roberto Chamorro, personal communications December 14, 1989 and February 19 and 21, 1990 (pond harvest estimate, 1989 and pond area data, 1987-90); AID, U.S. Embassy Tegucigalpa, February 4, 1991 and Chamorro, personal communications, February 19, 1991 (1990 pond harvest data, estimate based on export data), INFOPESCA, Noticias Comerciales, May 8, 1988 (pond area data); RENARE (1989 pond area data); and Chamorro, El Agricultor, January 8, 1990 (1995 pond area projection).

Appendix C.--Honduras. Principal shrimp farms, 1989

Farm	Pond Area	
	1987	1989
	Hectares	
Granjas Marinas San Bernardo	500	1,620
Aquacultivos de Honduras	NA	850
Cultivos Marinos (CUMAR)	260	300
Aquacultura Fonseca	200	300
Cultivadora de Camaron (CULCAMAR)	NA	300
Salinas de Honduras	280	NA
Sea Farms de Honduras	250	240
Amapala Agromarina	50	NA
Criaderos Marinos	50	NA
Others	170	NA
Total	1,760	NA

Source: Enrique Ramirez, Agropecuaticos, item 12.6.4, Aquaculture Digest, June 1987 (1987 data) and U.S. Embassy, Tegucigalpa, July 20, 1989 (1989 data).

Appendix D.--Honduras. Operational shrimp ponds, 1989-91

Farm	Pond Area 1989	1990	1991
	Hectares		
Granjas Marinas San Bernardo	1,620	2,000	NA
Aquacultivos de Honduras	850	1,000	NA
Cultivos Marinos (CUMAR)	300	520	NA
Cultivadora de Camaron (CULCAMAR)	300	420	NA
Aquacultura Fonseca	300	500	NA
Sea Farms de Honduras	240	240	NA
HONDUFARM	164	164	NA
INVERMAR	100	120	NA
Others	466	1,036	NA
Total	4,340	6,000	7,200

Note: Discrepancies with appendix B are unexplained.
Source: RENARE, March 28, 1989 (1989 data) and Chamorro, personal communications, January 28, 1991 (1990-91 data).

Appendix E.--Latin America. Cultured shrimp harvests, 1985-90

Country	Year 1985	1986	1987	1988	1989	1990
	1,000 Metric Tons					
Ecuador	30.2	43.6	69.2	70.1	64.2	70.0P
Colombia	0.1	0.1	0.5	1.2	3.0	7.0P
Mexico	0.1	0.2	0.8	2.4	3.2E	5.5P
Honduras	**0.6**	**1.3**	**1.9**	**4.5**	**3.4**	**5.0P**
Panama	2.6	2.5	2.8	3.5	4.0E	4.0P
Peru	1.1	1.2	2.0	2.3	4.0	NA
Brazil*	0.6	0.7	1.0	1.4	2.0	2.5P
Guatemala	0.5	0.6	0.8	0.8	0.8	1.4P
Others	0.8	1.0	1.0	1.6	1.8E	1.1P
Total	36.6	51.2	80.0	87.8	86.4	100.5

E - Estimated
NA - Not available
P - Projected
* Includes substantial quantity of freshwater shrimp.
Source: Variety of country sources

Appendix F.--Honduras. Shrimp exports and domestic consumption, 1980-88

Year	Domestic Consumption	Exports
	1,000 Metric Tons	
1980	Negl	2.4
1981	Negl	2.9
1982	Negl	3.0
1983	Negl	3.4
1984	Negl	2.3
1985	1.5	1.8
1986	1.5	2.1
1987	1.0	2.9
1988	NA	2.7*

* January-October
Source: INFOPESCA, personal communication, July 1990.

Appendix G.--Honduras. Cultured shrimp exports, 1986-90

Year	Quantity	Proportion*
	1,000 Metric Tons	Percent
1986	1.3	31
1987	2.3	NA
1988	3.7	NA
1989	2.6	60
1990	4.2**	NA

E - Estimated. Actual data available through September totals 1,640 tons.
* Percent of total shrimp exports.
** Some sources show greater amounts.
Note: Tail data in source converted to live weight.
Source: INFOPESCA (1986-88 export data) and Chamorro, World Shrimp Farming, May 1990 and U.S. AID, February 4, 1990 (1989 and 1990 export data and 1986/89 proportion data)

Appendix H.--United States. Shrimp imports from Honduras, 1980-90

Year	Imports	
	Quantity	Value
	1,000 Metric Tons	US $ Million
1980	2.1	15.2
1981	2.8	18.5
1982	3.0	18.4
1983	3.2	22.7
1984	2.4	17.0
1985	2.4	18.0
1986	2.5	24.5
1987	4.0	28.0
1988	4.1	32.3
1989	3.4	25.4
1990	4.1	28.4

Source: U.S. Bureau of the Census, various years.

3.6

MEXICO

Mexico is one of the Latin American countries with the greatest potential for culturing shrimp, along with Ecuador, Colombia, the Central American countries, and possibly Brazil. Mexico's **extensive coastline** and **tropical climate**, especially in the central and southern states, appear to offer a large area of potential sites suitable for shrimp culture. **Indigenous stocks** of a shrimp species highly suitable for culture is another major asset. Mexico also has considerable **experience** with processing and marketing shrimp. A strong **entrepreneurial spirit**, combined with relatively inexpensive **labor** and proximity to the U.S. **market**, bode well for Mexico's ability to develop an important shrimp culture industry. Major changes in Government policy appear to be eliminating basic legal impediments which impaired the industry's development during the 1980s. Improving commercial relations with the United States, especially prospects for a North American Free Trade Agreement, could have a dramatic impact on the industry's development by facilitating Mexico's access to U.S. investment capital and advanced aquaculture technology.

The country's potential, however, is yet to be fully demonstrated. Several factors may limit the industry's development. The **temperate climate** may impair results at farms located in northern Mexico, increasing operating costs and reducing yields. Other **physical factors**, such as soil and hydrological characteristics, have not been extensively evaluated. Arid conditions impair the development of many coastal sites. **Land ownership** patterns could also create difficulties, as much of the potentially suitable area in Mexico has been unavailable for private use because of laws protecting rural land-reform (*ejido*) communities. The quantity of **wild seedstock** available is not known, but appears insufficient to adequately supply the industry beyond the initial stage of development. In addition, the Government restricts the use along the Gulf coast of the Pacific species which yield the best results. Current reports suggest that pl production is increasing, but growers are still having problems obtaining wild postlarval seedstock and few hatcheries are currently in production. A lack of **basic infrastructure** may also impair development, as roads and utilities are poorly developed in areas of southern Mexico that appear best suited for shrimp culture. A shortage of **investment credit**, exacerbated by Mexico's on-going debt crisis and Government austerity program, continues to impede the industry's development.

Mexico's failure to effectively foster shrimp culture during the 1980s significantly impaired the country's overall shrimp industry, dominated by a Government-supported cooperative movement. Mexico had been the principal foreign supplier of shrimp to the U.S. market, relying almost exclusively on the traditional capture fishery conducted by the cooperatives. Increasing cooperative problems and adverse climatic conditions, however, have caused a sharp decline in both catches and export earnings since 1988. The declining earnings combined with reduced Government support has had a devastating impact on the cooperatives. In addition, Mexico has lost significant market share to competing countries like Ecuador, China, and Thailand, which dramatically increased shrimp exports by aggressively developing major shrimp culture industries.

The Government's initial efforts to promote shrimp culture were directed at cooperatives. Government policy erected **barriers** to both domestic and foreign investors, effectively preventing private investment. The Government's decision to restrict the culture of shrimp to cooperatives and *ejidos*, however, achieved poor results. The legal barriers also had the disastrous impact of limiting the industry's access to managerial talent and advanced technology. Many cooperatives showed little inclination to culture shrimp, which required much different lifestyle and job skills than the traditional capture fishery. Those cooperative groups which did attempt to culture shrimp encountered a variety of financial, technical, and managerial difficulties. Only a small number were able to manage successful farms. As a result, despite a decade of Government efforts, Mexican cultured shrimp harvests by 1986 were negligible. Though recent **legal changes** promise to significantly reduce or eliminate many of these barriers, their lingering impact on the industry's development may be felt for some time.

The Government, beginning in 1986, initiated major policy changes designed to promote a shrimp culture industry which would allow Mexico to regain a place among the principal world shrimp exporting countries. The Government initiated steps to open the industry to private investment. Revisions to the *Ley Federal de Pesca* permitted a limited role for private investment for the first time in 1986, while maintaining the exclusive right of traditional cooperatives to own and operate the farms. The Government followed further legal changes in 1987 with a long-range plan to promote the industry and expand the role of the private sector. After extended discussion, additional changes to the *Ley Federal de Pesca* were introduced in 1989 which further widened the scope of private industry, permitting investors for the first time to own and operate shrimp farms without a variety of costly legal fictions. Further legal changes introduced in 1992 may enable significant utilization of potential sites on *ejido* land, while further increasing the participation of private investment throughout the industry.

A full assessment of the Mexican shrimp culture industry's potential, however, remains difficult. Mexican variables are not fully assessed and growers face a variety of serious problems. Some question Mexico's ability to compete against countries with more favorable climates. Little information is available on actual operations at the increasing number of new farms. While the Government now allows private businesses (both domestic and foreign), as well as cooperatives, to culture shrimp, the final regulatory regime has yet to be determined. It remains to be seen how effectively the Government has removed institutional and financial barriers to the industry's development. A key indicator of the industry's future continues to be seedstock availability. New hatcheries are reporting serious production difficulties and SEPESCA efforts to support the cooperatives appear to be hindering wild collection. SEPESCA also continues to restrict postlarvae imports. The combination has limited seedstock availability and hampered the effective operation of some farms. Although a major hatchery construction program is underway, many observers expect continued technical problems for several years. Some observers believe that the industry, however, is slowly mastering the seedstock problem and that future expansion will be primarily limited by the ability to build and operate new farms.

Mexican industry sources, despite the problems they face, remain extremely optimistic. The fundamental changes of the legal framework have already had a striking impact on the industry's development. The private investors entering the industry, including important agrarian enterprises, have reported major successes, especially in the Pacific coast state of Sinaloa. Harvests have increased from only about 200 metric tons in 1985 to nearly 7,000 tons in 1990, making Mexico one of the largest Latin American producers. This sharp increase has dramatically demonstrated the vigor and capability of Mexico's private sector. Harvests could exceed 10,000 tons in 1992. While still a relatively small quantity compared to some of the major Asian producers, Mexican harvests have now reached the point that important numbers of growers are gaining experience and training an expanding group of technicians and farm managers. Rapidly expanding pond construction suggests that further major harvests will be achieved during the 1990s. Many observers believe that growers may be able to harvest about 25,000 tons by the year 2000, but some are projecting substantially larger harvests of up to 50,000 tons.

CONTENTS

I. CAPTURE FISHERY

Mexico conducts Latin America's largest wild shrimp fishery, with important grounds along both coasts (appendices E3 and E6). The country has an overall coastline of about 10,000 kilometers (km), with 6,000 km along the Pacific and 4,000 km along the Atlantic (Gulf of Mexico and Caribbean) (map 1). Mexico's Exclusive Economic Zone (EEZ) covers an area of about 715,000 square kilometers (km^2). The shrimp fishery is mostly conducted in estuaries and other inshore and shallow coastal waters.[1] Mexican fishermen rarely fish more than 40 km from the shore with the exception of fishermen based in the Atlantic-coast states of Campeche and Yucatán.

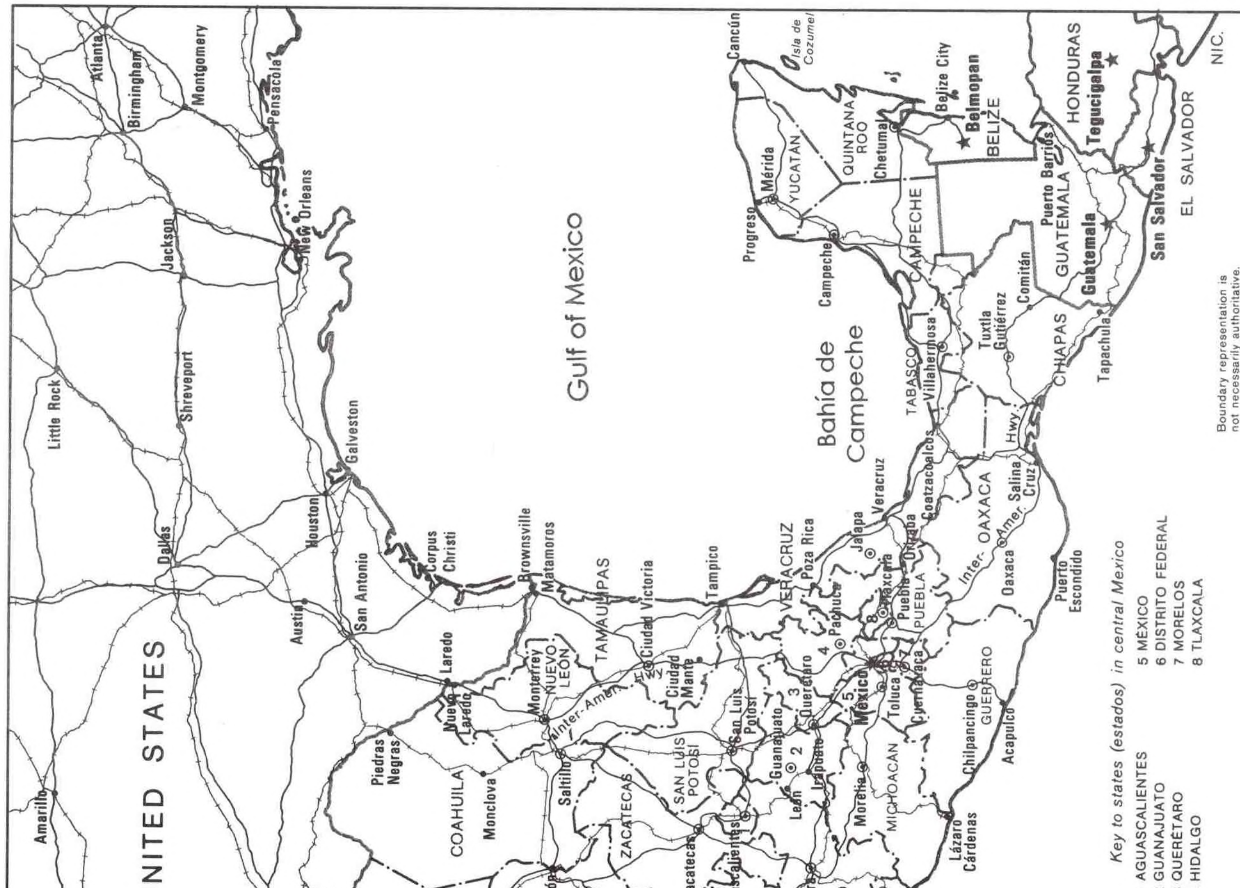
A. Physical Conditions

1. Pacific Coast

Mexico's most important shrimp fishery is conducted off the northern Pacific coast in the Gulf of California,[2] along the coast of Sonora and Sinaloa. Normally about 60-70 percent of Mexico's shrimp catch is taken along the Pacific coast (appendix E6).[3] The commercial fishery is conducted mostly in coastal waters on shallow grounds, but occasionally in waters as deep as 100 meters. Artisanal fishermen also take substantial quantities in estuaries and other inshore waters. The most important Pacific ports are Guaymas and Puerto Peñasco (Sonora state) and Mazatlán and Topolobampo (Sinaloa state). There is also a smaller southern fishery out of Salina Cruz (Chiapas state).

Sonora: The Sonora coast is wholly within the Gulf of California. The state has one of the longest coastlines of any Mexican state (900 km), lined with numerous bays and inlets, and an extensive continental shelf (9,200 km^2). The state is very arid, however, and few rivers flow into the Gulf.[4] As a result, Sonora does not have an extensive estuary system like that of neighboring Sinaloa.[5]

Sinaloa: Sinaloa, located directly south of Sonora, has a smaller coastline (650 km) with less continental


Mexico
International boundary
State (estado) boundary
National capital
State (estado) capital
Railroad
Road
0 100 200 300 Kilometers
0 100 200 300 Miles
Key to states (estados) in central Mexico
1 AGUASCALIENTES
2 GUANAJUATO
3 QUERÉTARO
4 HIDALGO
5 MÉXICO
6 DISTRITO FEDERAL
7 MORELOS
8 TLAXCALA
UNITED STATES
Gulf of Mexico
Bahía de Campeche
NORTH PACIFIC OCEAN
BAJA CALIFORNIA NORTE
BAJA CALIFORNIA SUR
SONORA
CHIHUAHUA
COAHUILA
NUEVO LEÓN
TAMAULIPAS
SINALOA
DURANGO
ZACATECAS
SAN LUIS POTOSÍ
NAYARIT
JALISCO
COLIMA
MICHOACAN
GUERRERO
OAXACA
PUEBLA
VERACRUZ
TABASCO
CHIAPAS
CAMPECHE
YUCATÁN
QUINTANA ROO
BELIZE
GUATEMALA
HONDURAS
EL SALVADOR
NIC.
ISLAS REVILLAGIGEDO
ISLAS MARÍAS
Boundary representation is not necessarily authoritative.
Base 801219 (546155) 8-88

Map 1.--Mexico.

Photo 1.--Mexico. The deteriorating shrimp fleet has reported sharply lower catches since 1989. Dennis Weidner

shelf (5,900 km^2). Sinaloa does have, however, an extensive system of estuaries, lagoons, salt marshes, and bays, especially along the central and southern coast. The esturine system provides an ideal nursery environment. Normally heavy precipitation during the summer rainy season washes nutrients into the estuaries, supporting the development of juvenile shrimp. As the rains end during September or October, the juveniles begin to mature and move offshore.[6]

2. Atlantic Coast

There are two major shrimp fisheries in the Gulf of Mexico. The most important fishery is conducted on the Campeche Bank out of Ciudad del Carmen and Campeche (Campeche state). The smaller fishery is conducted in the northern Gulf out of Tampico (Veracruz state) and Matamoros (Tamaulipas state). A smaller fishery for rock shrimp and other species has developed off the northeast coast of the Yucatán Peninsula, but the catch is only a fraction of that taken in the two more established fisheries.

Tamaulipas and Veracruz: The fishery off these two states is conducted on trans-boundary stocks which migrate north and south across the U.S.-Mexican border. Mexican and United States scientists are studying the extent of this migration. The Laguna de Términos and the Laguna Madre are the primary nursery areas.

Campeche: Campeche has an extensive esturine system and a continental shelf extending 250 km into the Gulf of Mexico (the Campeche Bank). The combination of shallow water, a muddy-sandy bottom, and nearby nursery habitat combine to make the Campeche Bank Mexico's most important Gulf shrimp fishing ground.[7] The coastline extends about 780 km from 90° to 93° West Longitude. The total area of the state's continental shelf is about 115,000 km^2. The fishery is primarily conducted on the Campeche Bank, but areas off Yucatán and Tabasco are fished to a lesser extent. The mangroves and inlets along the western coast of the Yucatán Peninsula serve as the principal nursery area for the pink shrimp taken on the Campeche Bank. The high tidal range provides a substantial flushing action along the coast, creating excellent conditions for pink shrimp which do not require low salinity levels for a nursery habitat. The Laguna de Términos in southern Campeche, is the most important esturine nursery system in the Gulf, but Mexican officials believe that it primarily serves as a nursery ground for the brown and white shrimp taken off Tabasco and Veracruz.

Yucatán/Quintana Roo: Only a small fishery is conducted off the northern coast of the Yucatán Peninsula. Catches are primarily pink and rock shrimp. The largest rock shrimp catches are reportedly to the north and west of Contoy Island.

B. Catches

Mexico was the first Latin American country to initiate a commercial shrimp fishery. Mexican fishermen have harvested and exported substantial quantities of shrimp for over 50 years (appendix K9). The fishery continues to be the largest in Latin America and is second only to the U.S. fishery in the Western Hemis-phere. The only other Latin American shrimp fishery of comparable site is that conducted in Brazil. The Mexican wild catch reached a record high of 83,000 tons (t)[8] in 1987, but has since declined (figure 1). The 1990 harvest fell below 60,000 t, and available reports indicate that the 1991 harvest was about 50,000 tons (appendix E7).[9] Preliminary reports indicate only limited improvement during the 1992 season.

The cause of the decline in Mexico's capture fishery is not fully understood. Some Mexican biologists believe that climatic factors, especially water temperatures, are the principle cause.[10] Others believe abnormally low rainfall reduced wild stocks. A variety of other environmental factors may be affecting the catch.[11] Some observers point to increased pesticide and silt run-off in recent years, the result of expanded agricultural activities in northern Mexico.[12] The deteriorating condition of the cooperative fleet is another contributing factor.[13] Others believe that the substantial, but difficult to quantify, illegal catch by poachers is adversely affecting yields.[14] The poachers take large amounts of juvenile shrimp in the estuaries, reducing the catch of more valuable, larger shrimp in the offshore trawl fishery.[15] Most of the illegal catch is not accounted for in Mexico's statistics, and is sold surreptitiously in the domestic market. The extent of the illegal fishing leads some to question the validity of official statistics. How much of the current shortfall in harvests can be attributed to inadequate statistics rather than an actual decline in the fishery due to changing weather patterns, poor cooperative management, and other factors, remains unclear.

Some observers anticipate that Mexican shrimp catches could begin recovering in 1992 and 1993. The reentry of private vessel owners into the fishery will make better maintained and newer vessels available to the fishermen. Some observers anticipate that the number of new or used trawlers made available to the fishermen by private interests could be substantial.[16] A considerable number of used U.S. trawlers were purchased in 1991, but details on the actual number are unavailable. The Government is also sponsoring a program to help add 300 new vessels during 1992-94.[17] New vessels are badly needed because the cooperatives have added few new trawlers to the fleet since acquiring privately owned trawlers in 1981-82. In addition, normal climatic fluctuations may create better growing conditions. Even minor improvements in climatic conditions could enable the fishermen to achieve some increase over the abnormally low 1990 and 1991 catches.

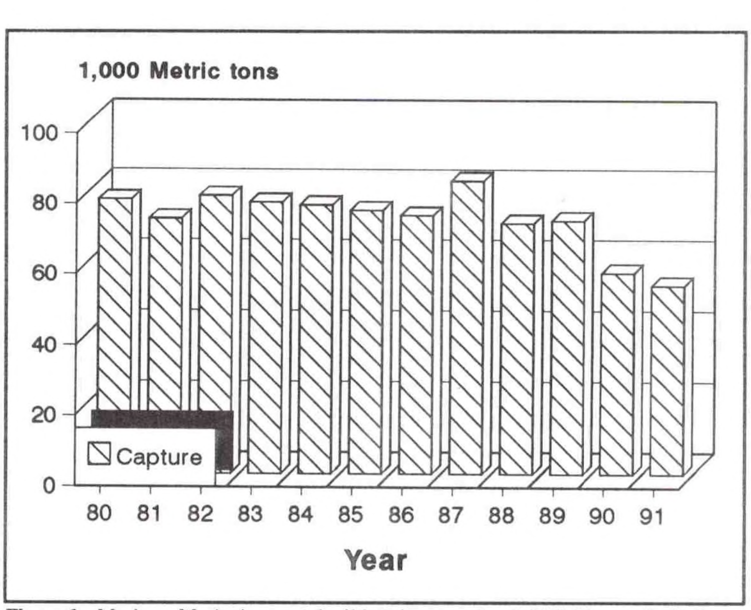


Figure 1.--Mexico. Mexico's annual wild shrimp catches held fairly steady during the 1980s, but have since declined.

II. AQUACULTURE INDUSTRY

The Mexican Government has attempted to promote the development of the country's aquaculture potential.[18] SEPESCA officials are convinced that the country has the natural, technical, and human resources to develop a very significant aquaculture industry.[19] The size of the country and its climatic diversity provide suitable growing conditions for a wide variety of species. Private investors built the first cultured operations, which stocked trout, catfish, and a few other finfish species. Most were relatively small operations.

The Mexican Government initiated a major aquaculture development program during the early 1970s. Important investments of public funds were made to expand the new industry. The initial focus of the Government's aquaculture policy was to increase harvests of low-cost species to expand domestic food supplies. The Government opened various research stations to conduct aquaculture research and funded extensive work at a large number of universities.[20] The Government also initiated basic training programs for aquaculture technicians. The various research and training programs have created the foundation for the future development of an important new industry. The Salinas Government considers aquaculture to be a high priority and has initiated a new aquaculture program, the Programa de Modernación de la Acuacultura (PMA), which projects major harvest increases by 1994.[21]

The Government also financed a variety of actual growout operations. The effort benefitted both private growers and cooperatives, but priority was given to assisting cooperative groups. Officials gave special attention to tilapia, carp, and a variety of other species. The species were selected because they required relatively basic, low cost technology. The Government has also financed more technologically advanced work on species requiring more difficult hatchery and growout systems, such as shrimp (marine and freshwater) and various mollusks including abalone.[22]

Some observers claim that Mexico is developing a major aquaculture industry. One 1991 report claimed that Mexico had over 2,300 aquaculture operations, including catfish (427), trout (183), shrimp (111), oysters (77), and other species (1,513).[23] Specific details on these operations are not available. Many appear, however, to be non-producing projects. The number of catfish farms, for example, seems to be wildly excessive.

Accurate data on total cultured harvests is difficult to assess because there are such varying estimates. The Mexican Government reported a harvest of nearly 185,000 t in 1988.[24] Much of this, however, was actually caught in freshwater fisheries. The Government stocks many lakes and reservoirs, but such operations are not true cultured harvests.[25] The species involved are primarily tilapia, mojara, and carp. Actual harvests in 1989 using a more restrictive definition of aquaculture probably totaled only about 60,000 tons.[26] SEPESCA hopes to significantly increase its cultured harvests under the PMA and some observers insist that the country is achieving major harvest increases.[27] Other observers are critical of Mexico's aquaculture program, noting that the country has still achieved only a relatively small harvest, given the major Government investments.

Shrimp is now emerging as Mexico's single most important cultured species. It is currently the second leading cultured species in terms of quantity, but already the most important in terms of value.[28] The Government decided in 1985 to give priority to shrimp culture, as part of a larger effort to increase foreign exchange earnings. Mexico's declining share of the U.S. shrimp market and falling real export earnings during the 1980s have been the driving force behind the Government's decision to promote a shrimp culture industry.[29] Despite the Government's promotional efforts, the legal impediment to private investors restricted the industry's development. Observers now report that the 1986 and 1989 modifications of the law regulating shrimp culture have provided a major impetus for the industry's development. (See Section VII. Legal and Social Framework.)

III. SPECIES

Mexican shrimp fishermen catch a variety of marine species (appendix B1). A detailed statistical breakdown of the catch by species is not available. The most important species taken in the Pacific coast fishery is probably brown shrimp (*Penaeus californiensis*). In the Gulf of Mexico, the most important species taken in the Campeche fishery is pink shrimp (*P. duorarum*) and in the Veracruz/Tamaulipas fishery brown shrimp (*P. aztecus*). The smaller fishery in the Caribbean off Contoy Island targets pink spotted (*P. brasiliensis*) and rock shrimp (*Sicyonia brevirostris*). A glossary of the English, Spanish, and scientific names for shrimp species occurring off Mexico is provided in appendix B1.[30]

Shrimp growers in Mexico, as elsewhere in Latin America, have primarily focused on *P. vannamei* and *P. stylirostris*. These two species occur off the Pacific coast, but are not the dominant species. There have been limited trials with many other species. Shrimp growers have conducted at least informal trials with *P. aztecus*, *P. californiensis*, *P. duorarum*, and *P. setiferus*.[31] Very little information is available about the results achieved using these species, but the experience of other Latin American countries with most species other than *P. vannamei* and *P. stylirostris* is not encouraging.[32] The fact that Mexican growers are all reportedly using *P. vannamei*, and to a limited extent *P. stylirostris*, suggests that Mexican growers have also had little success with these other species.

A. Marine

1. Pacific Coast

Mexico's Pacific shrimp fishery is primarily directed at brown shrimp (*P. californiensis*) although two species of white shrimp and a pink shrimp are also of some importance.[33]

P. californiensis: This species of brown shrimp occurs from San Francisco Bay in California south to Bahía de Sechura in Peru, although some reports extend its range even further south to Chile. It is the single most important species taken by Mexican fishermen and can reportedly account for as much as 75 percent of the offshore Pacific trawler catch. It is usually found at depths of 15-100 meters (m), but is most abundant from 25-50 m on soft muddy or sandy bottoms. Juveniles are abundant in offshore waters, especially at depths from 40-80 meters. The juveniles tend to appear with adults in the offshore habitat, but rarely enter estuaries because they cannot tolerate the sharp swings in salinity and temperature that occur there. The maximum size of the species is 160 millimeters (mm) for males, 210 mm for females. Mexican researchers have conducted some work assessing the species' potential for pond culture.[34] No growers anywhere in Latin America are known to be using the species, however, probably because of its lack of tolerance for the estuary-like pond conditions.

P. stylirostris: This species of white shrimp is found from Punta Abreojos in Baja California south to Tumbes in Peru. Mexican fishermen often refer to it as "camarón azul" (blue shrimp). Adults inhabit soft muddy clay or sandy bottoms from the beach to a depth of about 27 meters. While the adults are found offshore, the juveniles are generally found in bays and estuaries. Off Mexico, their presence is especially concentrated in the bays and estuaries of Sonora, Sinaloa, and northern Nayarit during spring and summer. The maximum length is about 230 millimeters. Some Latin American growers have used *P. stylirostris*,[35] usually in conjunction with *P. vannamei*. Farms in Panama and Honduras have reported commercial success with *P. stylirostris*[36] and Mexico's experimental farm at Puerto Peñasco reportedly achieved impressive results with the species. *P. stylirostris* is somewhat more tolerant of cold water temperatures[37] than *P. vannamei*, and several growers in northern states have expressed interest in culturing *P. stylirostris* during the winter and *P. vannamei* during the summer.[38] Growers report that they are able to grow larger shrimp with *P. stylirostris* than with *P. vannamei*, though survival characteristics and yields are lower. *P. stylirostris* also requires higher quality feed, which is more costly and reportedly difficult to obtain in Mexico.[39] (See Section XV. Feed.)

P. vannamei: This species of white shrimp occurs from Sonora in the Gulf of California south to Tumbes in Peru. The regions of principal abundance off Mexico are the coastal waters of Sonora, Sinaloa, Nayarit, Oaxaca, and Chiapas. Adults can be found very close to the beach out to a depth of 70 m on muddy bottoms. Juveniles are found in large numbers in estuaries, especially in southern Sinaloa and northern Nayarit. Of all the Mexican species, *P. vannamei* seems to adapt the best to estuarine conditions. Juveniles can tolerate the sharp swings of salinity, temperature, pH, and dissolved oxygen levels which often occur in estuaries.[40] This probably explains why the species does so well in ponds, where conditions are similar to the estuaries and are subject to sharp swings. As a result, *P. vannamei* is preferred by most Latin American shrimp farmers, who report extremely favorable survival and growth rates. The species can be cultured using inexpensive feeds that have protein content as low as 20-25 percent. The favorable results with low-cost feed is a substantial advantage over *P. stylirostris*. (See Section XV. Feed.) The species is widely used in Mexico's Pacific coast farms, but Mexico has stringent regulations concerning the use of exotic species. The Gulf/Caribbean growers may have difficulty obtaining permits to use this species.[41]

P. brevirostris: This species of pink shrimp ranges from Sinaloa south to Peru and the Galapagos Islands. It occurs at depths of 35-120 m on sandy or mud bottoms. Off Mexico, it is of commercial importance, but less so than the brown and white shrimp which dominate the fishery. The authors know of no Mexican growers currently using the species.

2. Atlantic Coast

The major Mexican Atlantic-coast fishery is conducted on the Campeche Bank for *P. duorarum*. A smaller fishery off Tampico and Veracruz is conducted primarily for *P. aztecus*. Several other species, however, are of some commercial importance.[42]

P. aztecus: This species of brown shrimp occurs from Massachusetts south to the Campeche Bank. It is the most important species taken in the northern Gulf of Mexico and dominates Mexican catches off Tamaulipas and Veracruz.[43] Occasionally, however, *P. aztecus* catches are exceeded by *P. setiferus* catches. *P. aztecus* is found at depths of 4-160 m, but most commonly between 25-55 m on mud or peat bottoms, frequently with sand, clay, or broken shells. Adults are found almost exclusively in ocean water, while the juveniles are found both in the ocean and estuaries. The maximum length is 195 mm for males, 235 mm for females.[44] Mexican researchers have done some preliminary work on this species, but no growers are known to be using it.[45]

P. brasiliensis: This species of brown shrimp occurs

Photo 2.--Mexico. Despite considerable interest, freshwater shrimp has not yet proven commercially viable. Dennis Weidner

from North Carolina south to Rio Grande do Sul in Brazil. It is not one of the most important species in the Gulf but tends to dominate catches in the smaller Caribbean fisheries off Contoy Island and along the coast of Quintana Roo. It is found at depths of 3-365 m, but is most abundant at 45-65 meters. It prefers mud or muddy sandy bottoms. The maximum length is 190 mm for males, 150 mm for females.[46] Some Brazilian growers have attempted to use this species, but results have been disappointing.[47] No Mexican growers are known to be using it, but SEPESCA is reportedly encouraging groups Yucatán and Quintana Roo who are interested in shrimp culture to use the species.

P. duorarum: This species of pink shrimp occurs from Maryland south to Quintana Roo along the eastern coast of Mexico's Yucatán Peninsula. It is the principal species taken by Mexican Gulf fishermen and dominates catches on the Campeche Bank. The species is found at depths of 2-70 m, but is most common at 10-35 meters. It prefers a bottom of fine mud and silt mixed with sand and shells. Juveniles can survive in waters with low salinity, but the adults are marine. The maximum length is 270 mm for males, 280 mm for females.[48] No Mexican growers are known to be using it.

P. setiferus: This species is the principal species of white shrimp taken in the Gulf of Mexico. It occurs from New Jersey south to the Campeche Bank, but the principal commercial fishery is conducted in the Gulf. Most of the Mexican catches are reported on the Campeche Bank. It is found at depths of 2-90 m on mud or peat bottoms, sometimes mixed with sand or clay. The maximum length is 175 mm for males, 200 mm for females. No Latin American growers are known to be using this species. One Mexican grower currently building a shrimp farm in Yucatán is considering using this species in some of his ponds, primarily because SEPESCA is encouraging the use of indigenous species.

Sicyonia brevirostris: This species of rock shrimp is found in shallow water to a depth of 180 meters and prefers a bottom with white shelly sand. Off Mexico it is most common around Contoy Island off the northeast corner of the Yucatán Peninsula. The authors know of no pond trials using this species.

B. Freshwater

Several species of freshwater shrimp occur in Mexico (appendix B1). Only limited information is available to the authors on these species.[49] Most of the available information concerns the exotic species (*Macrobrachium rosenbergii*) imported by growers.[50]

IV. GROWING CONDITIONS

The climatic and physical conditions faced by Mexican shrimp farmers vary widely. Mexico is a large country, with extensive coasts along two oceans. There is a wide range of coastal climatic conditions, varying from dry and temperate in the north to humid and tropical in the south, with a great variety in between. Water temperatures, tidal ranges, precipitation, freshwater sources, salinities, soil characteristics, pH levels, and other conditions differ markedly between the Pacific and the Atlantic (Gulf of Mexico/Caribbean) coasts, and between the northern and southern latitudes along each coast (figures 2 and 3). The authors have only limited information on these conditions.

Water quality varies widely, depending on population concentration and the extent and form of industrial, petrochemical, and agricultural

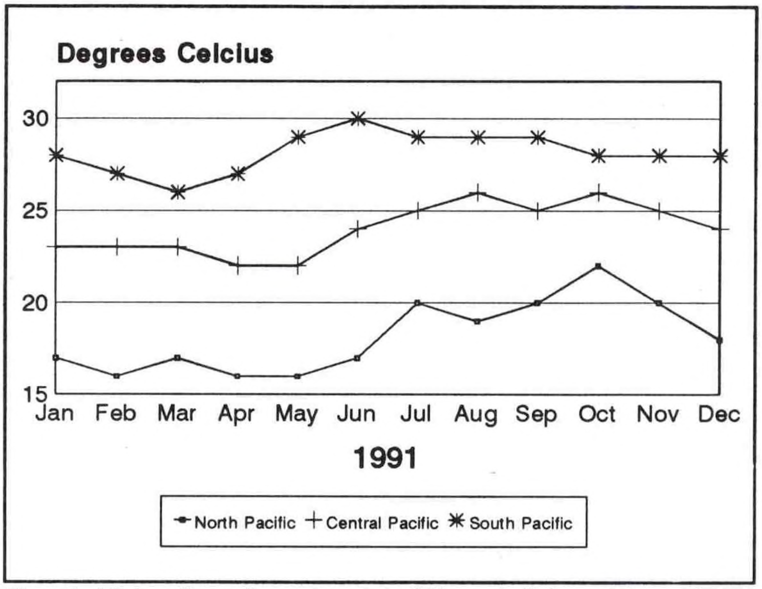


Figure 2.--Mexico. Sea surface temperatures differ markedly between the northern and southern latitudes along the Pacific coast.

development. Such development can impair the fragile coastal ecosystem upon which wild shrimp stocks are dependent. Water quality seriously affects growing conditions in the ponds. A major pond construction program in a specific area could itself affect the local estuarine environment, either by cutting the mangroves or from the substantial volume of pond effluent discharged by active ponds.

A. Environment

1. Pacific Coast

Many observers note the apparently favorable conditions for culturing shrimp along Mexico's Pacific coast. Available data suggest that from central Sinaloa south, climatic conditions may be highly conducive to successful shrimp culture operations. Lower water temperatures, and more limited freshwater resources as one moves north along the coast may reduce yields and limit the seasonal use of ponds, making commercial shrimp operations less profitable.

Northern states: Climatic conditions along Mexico's north Pacific coast, in particular seasonally low temperatures and limited precipitation, may present significant limitations to growers, though both problems are somewhat mitigated as one moves south. Limited freshwater resources present an additional serious problem in the northern states. The sparse rainfall means that freshwater to adjust pond salinities is limited. Annual precipitation ranges from less than 250 mm in northern Baja California to 600 mm in central Sonora.[51]

The Baja and Sonora: Average sea surface temperatures along Sonora and the eastern coast of the Baja are below 20° Celsius (C) for much of the year.[52] Sea surface temperatures in the cold winter months can fall as low as 13°C. Not only do temperatures off northern Mexico drop during the winter, but growers face a substantial daily variation during the year, much greater than off Ecuador (appendix C1). Even a brief cold snap could decimate an entire crop. As a result, the most northerly growers will have difficulty making full, year-round use of extensive or semi-intensive growout ponds, which are exposed to ambient temperature changes.[53] A few growers have opened farms in Sonora and are testing the area's suitability for shrimp culture.

Sinaloa: Growers in northern Sinaloa face many of the same climatic problems faced by Sonoran growers. Significant sea surface temperature gradations occur, however, between the northern and southern zones of the Gulf of California (appendix C2).[54] Conditions in Sinaloa, especially in the southern parts of the state, appear to be much more

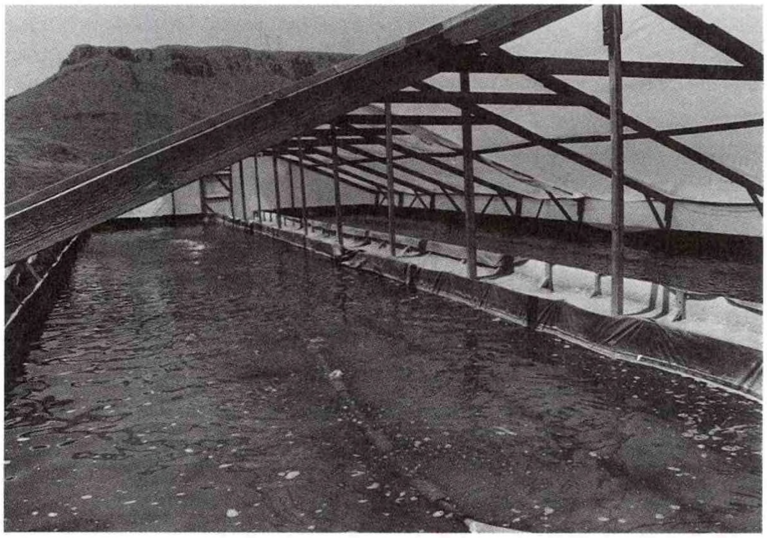


Photo 3.--Mexico. Covered nurseries for late-winter pl seeding at Maricultura de Sonora near Guaymas in northern Mexico. © Leland Lai, Aquafauna Bio-Marine

favorable for tropical species than in Sonora.[55] Average monthly sea surface temperatures in southern Sinaloa are generally between 20-25° C even from December through March, the coldest months of the year, and above 25° C from May to November.[56] Low precipitation levels in northern Sinaloa are very similar to those in Sonora and Baja California. Freshwater supplies, while still limited, are more abundant in portions of southern Sinaloa, including the large estuarine areas of the Teacapán peninsula.[57] The superior conditions in southern Sinaloa are confirmed by the success being reported by large numbers of growers. (See Section X. Farms and Farm Ownership, and Appendices E13, G1 and G4.)

Central states: The environmental potential for shrimp culture in Nayarit, Jalisco, Michoacán, and Guerrero is not well known. Several observers are convinced that conditions are especially favorable in Nayarit, which has an important estuarine system and where water temperatures are somewhat higher and less influenced by seasonal fluctuations than in Sinaloa and the other northern states. From Jalisco south, water temperatures are higher and generally more stable, averaging above 23° C all year round (appendix C2). Some observers are very optimistic about the area's potential for pond culture. Little data is available to the authors, however, concerning rainfall, freshwater supplies, pH levels, soil conditions and other environmental factors in the region.

Southern states: The southern-most states of Oaxaca and Chiapas appear to offer favorable climatic conditions for shrimp culture.[58] Water temperatures along the southern Pacific coast average about 25° C (appendix C2). Annual temperature variations are much smaller than off northern Mexico and comparable to Ecuadorean levels (appendix C1). Chiapas appears to have excellent natural conditions for shrimp culture, including more rainfall than the northern and central states, plentiful freshwater throughout the year, and large estuarine areas.[59] Several successful projects across the border in northern Guatemala suggest that shrimp can also be cultured in southern Mexico.[60] One observer reports, however, that aerial surveys of Chiapas combined with on-site investigations indicate notable problems.[61] Those areas most suitable for large farms (i.e. level land with clay soils) appear to occur in areas subject to sharp salinity swings.[62] Less is known about conditions in Oaxaca, but the large estuarine system in the southeastern part of the state near the Chiapas border may offer good potential sites. The more rugged coastal geography further north and west, however, provides few level sites, while heavy wave action creates engineering difficulties in obtaining seawater.[63]

2. Atlantic Coast

The Atlantic (Gulf of Mexico/Caribbean) coast states appear to have extensive areas that seem suitable for shrimp culture.[64] Average temperatures are higher along the Atlantic coast than for similar Pacific latitudes (appendix C2), tidal ranges smaller,[65] and precipitation generally higher (especially in the north). The most serious problem appears to be the difficulty obtaining appropriate pl seedstock rather than unacceptable environmental conditions.[66] One observer is convinced that shrimp can be cultured along the Gulf, and that limited financing and the inexperience of initial growers have caused the failure of the initial projects.[67] Colombian growers have clearly demonstrated that shrimp can be successfully cultured along the Caribbean/Atlantic coast.[68] Most other Atlantic coast countries have, however, reported difficulty developing a shrimp culture industry. The level of difficulty encountered by Mexican Atlantic-coast growers suggests some underlying physical problems may exist.

Northern Gulf states: Limited success by U.S. growers along the southern Texas coastal plain would seem to indicate that the similar environmental

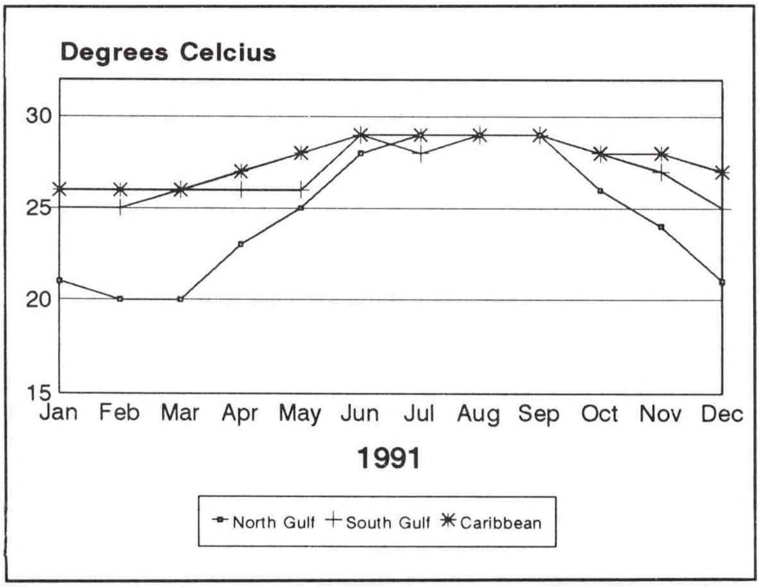


Figure 3.--Mexico. Sea surface temperatures in the northern Gulf of Mexico exhibit substantial declines during the winter.

conditions along the coast of Tamaulipas and northern Veracruz would support shrimp culture.[69] Some Texas growers are convinced that only minimally higher temperatures would sharply improve their results. Many observers believe that the warmer temperatures available to Mexican growers may permit successful results. Unlike Texas, extensive areas of coastal land are not being used and could be purchased at relatively low cost.[70] Little detailed information, however, is available to the authors on physical conditions such as soil characteristics, pH and salinity levels. Some observers have noted a hyper-saline condition in Mexico's portion of the Laguna Madre, though the salinity levels appear to be somewhat lower than those found in the Laguna Madre along the Texas coast.[71] At least one experimental effort to culture *P. vannamei* at Soto la Marina, Tamaulipas, has reportedly achieved modest results.[72]

Southern Gulf and Caribbean states: Climatic conditions would seem to favor the southern Gulf and Caribbean coast states, including southern Veracruz, Tabasco, Campeche, Yucatán, and Quintana Roo. Warmer water temperatures should permit year-round use of ponds (appendix C2). Water salinity levels are reportedly more suitable in the southern Gulf, such as at Laguna de Términos in Campeche. However, sandy soils from Tampico south could make pond construction difficult. Porous soils on the Yucatán Peninsula may complicate pond construction. The limited availability of surface freshwater in the Yucatán Peninsula is another serious problem. More detailed climatic and physical information is becoming available, sponsored by regional university groups.[73] There is a considerable area of mangrove estuaries, often seperated from the ocean by estuaries but with only occasional outlets to the ocean.[74] An additional problem may be the interests of SEPESCA, SEDUE and other agencies to protect mangrove areas from commercial exploitation.[75] The Centro de Investigación y de Estudios Avanzados del IPN (CINESTAU) assessed shrimp culture in Yucatán, however, and concluded that favorable conditions exist, including soil types, pH, and available subterranean freshwater.[76] SEPESCA is currently contracting for a Sinaloa consultant to assess conditions in Quintana Roo.[77] Another specialist is convinced that aquaculture projects are possible. The suitability of the area for shrimp culture, however, is not well tested as there have been few actual trials. Government officials believe that appropriate sites exist all along the Gulf and Caribbean coast. One researcher is convinced that shrimp can be cultured in Yucatán and that the lack of progress to date reflects the reluctance of investors to commit to a new industry and to any physical restraint.[78] A SEPESCA official believes that shrimp can be culture in Quintana Roo, especially in the northern section of the state.[79] Only one farm has been built in Campeche, but it has been closed for several years.[80] One farm is under construction in Yucatán.[81] There are no active ponds in Quintana Roo.[82] No commercial farms are currently active in the Yucatán Peninsula. Some observers are optimistic about the potential in Quintana Roo.[83]

B. Water Quality and Pollution

Water quality is a critical factor for shrimp farming. The limited availability of freshwater will cause difficulty for growers in many coastal areas. Growers also have to consider water quality, including factors such as salinity, pH, suspended solids, organic matter, photoperiod, nutrients, plankton, dissolved oxygen, circulation, pollutants, and many other factors. Comprehensive data on these factors in Mexico is not available to the authors and, as a result, it is not currently possible to assess either water quality or the extent of coastal pollution.[84] Some general statements are possible. Growers in many coastal areas have access to relatively extensive areas that do not appear to be significantly impaired by serious pollution. Mexico is, however, one of the most industrialized and heavily populated Latin American countries and as a consequence has a variety of serious environmental problems affecting water quality.[85] Few Mexican cities have modern waste treatment centers. The Government is just beginning to address these problems. The Secretaria de Desarrollo Urbano y Ecología (SEDUE) is reportedly preparing an action plan designed to deal with the country's growing water pollution problem.[86] A combination of urban sewage, industrial pollution, petrochemical contamination, and agricultural chemical runoff has affected fisheries in scattered locations along both coasts.[87]

The limited area of ponds constructed thus far has generally taken place in less polluted areas, but as the industry develops it may encounter increasing problems obtaining unpolluted water. Some growers have already encountered such problems. In one case in Guerrero state, a hydroelectric plant allegedly polluted water which local farmers were using for freshwater shrimp culture -- killing newly-seeded postlarvae.[88] Pollution may be an especially serious constraint in the large areas of northern and central Mexico which are extremely arid. The scarcity of freshwater makes local rivers and lakes more

***Photo 4**.--Mexico. A substantial portion of the ponds which growers built in recent years remain unused.*

vulnerable to pollution and offers growers fewer alternatives than in areas with more abundant rainfall and river systems.

Shrimp farms can themselves have a major impact on coastal ecosystems. The need to exchange water forces pond managers to discharge large volumes of effluent into the local estuaries. The effluent contains heavy concentrations of organic material as well as fertilizer used by the growers. Smaller concentrations of chemicals and drugs are a further concern. The effluent flow is at present limited by the relatively small number of ponds in operation. The clustering of ponds, such as the current concentration in parts of Sinaloa, is already producing substantial effluent flow in specific areas. The large area of ponds projected for development could eventually produce very significant effluent volumes. Such large volumes could affect both pond operations and the ecology of the surrounding coastal areas. Pond operations may be affected because growers use rivers and estuaries for water exchange, the same bodies where they discharge the effluent. As the estuaries play a big role as nursery areas, the increasing volume of effluent could significantly impair the availability of pl both for stocking shrimp ponds and recruiting for the capture fishery. Without major hatchery production, any reduction in the abundance of wild pl would make it difficult for growers to stock ponds. (See Section XIV. Postlarval Supply.) Other associated problems such as cutting mangroves and reducing estuarine area through coastal development could further impair the local ecosystem.

SEDUE reports that existing growers have not taken adequate care to protect the environment. SEDUE is concerned about this and the future major expansion of the industry. SEDUE has decided to more carefully evaluate the environmental impact statements submitted by new growers and not approve those statements until they fully meet legal requirements for the protection of wetlands.[89]

V. POND AREA

A. Potential

The potential area suitable for shrimp culture in Mexico is simply not known with any precision. A variety of observers, however, have attempted to estimate the country's potential. While these estimates vary widely, all observers agree that a very large area could be developed (appendix D1). SEPESCA estimated in 1987 that over 350,000 hectares (ha) of ponds could be built. SEPESCA

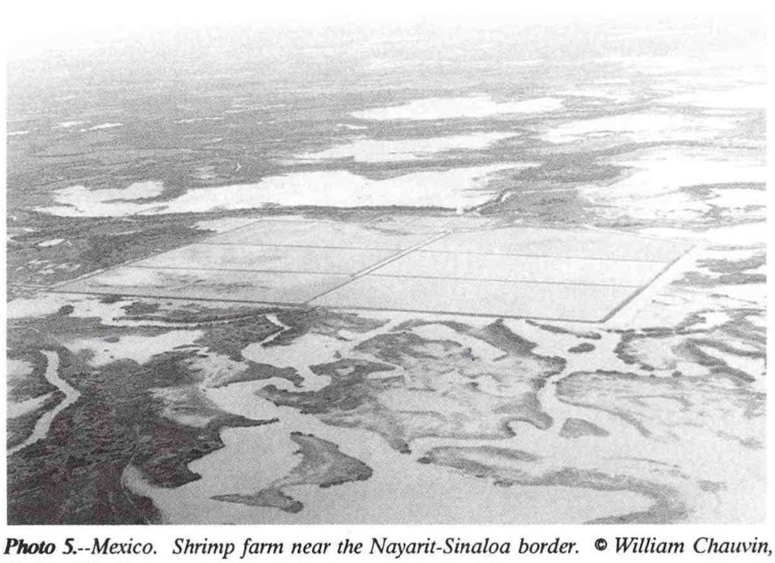


***Photo 5**.--Mexico. Shrimp farm near the Nayarit-Sinaloa border. © William Chauvin, Shrimp World*

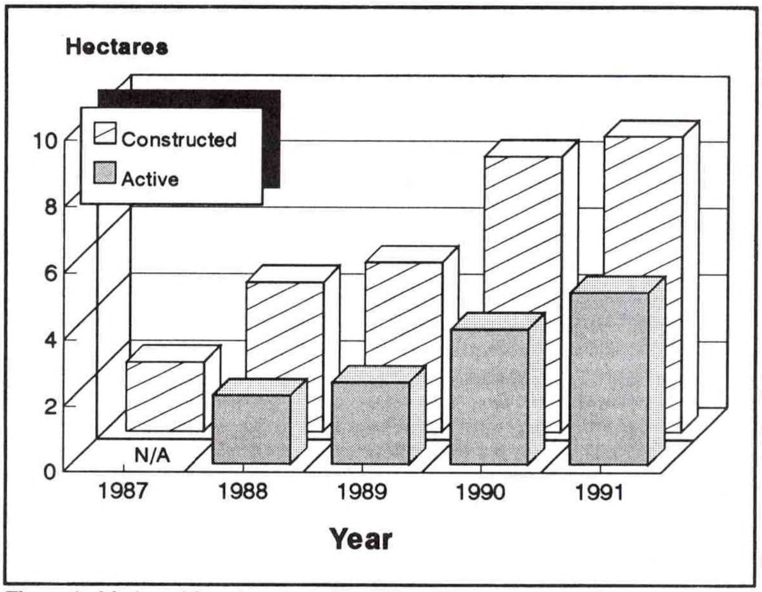


Figure 4.--Mexico. Many constructed ponds continue to go unused.

now estimates that more than 750,000 ha of land is suitable for shrimp ponds.[90] Some other estimates exceed 800,000 hectares. This immense area could equal the potential pond area in all the rest of Latin America combined. Such optimistic estimates, however, should be viewed with considerable caution. Little information is available on the criteria SEPESCA used in preparing its estimates, and they are known to include marginal grazing and agricultural lands as well as estuarine areas.[91] The authors know of no comprehensive survey conducted to assess potential pond area. As noted above, much basic data on key physical factors are unavailable. Many coastal areas have not been carefully assessed by experienced shrimp culture specialists. The larger estimates may eventually prove to be wildly over-optimistic, especially as temperature constraints mentioned above may prevent the use of extensive areas along the northern coast (especially along the Baja, Sonoran, and Tamaulipas coast). (See Section IV. Growing Conditions.) Even with these reservations, however, there do appear to be very substantial areas which are suitable for pond culture.

B. Constructed

Growers have so far developed only a small portion of Mexico's available sites (appendices D1 and D2). Observers vary considerably on actual pond area, with estimates ranging from 5,000-11,000 hectares.[92] One cause for the discrepancy may be that a substantial area of ponds have been built but remain unused (figures 4). SEPESCA released a national aquaculture inventory in 1990 that indicated a total marine and freshwater shrimp pond area of 10,700 ha.[93] A more detailed listing of marine farms showed a total pond area of only 8,300 ha in 1990.[94] Others provide somewhat lower estimates. One observer estimated in 1990 that Mexico's total area of constructed ponds was about 7,000 hectares.[95] Officials at the U.S. Embassy in Mexico City in mid-1990 estimated even more conservatively that completed ponds totaled only about 5,000 ha, based on information obtained from local sources.[96] Most of Mexico's shrimp farms are currently located in Sinaloa.[97] Sinaloa SEPESCA officials reported that the state's 1990 pond area (including ponds under construction) totaled 7,600 hectares.[98]

C. Utilization

Valid assessments of pond utilization in Mexico are impossible because of the lack of adequate data. The limited data available, however, suggest that large numbers of existing ponds are not being operated. Unconfirmed reports in 1988 and 1989 indicated that growers were stocking only about half of their ponds (figure 4 and appendix D2). Data are not available for 1990 and 1991. Reports in mid-1991, however, point to continued low utilization of existing ponds. A major factor seems to be the difficulty in obtaining pl, though other factors are clearly involved. The low utilization rate also probably reflects the inability of cooperative groups to profitably operate many of their farms. Another factor is that some farms were not well designed and have apparently been abandoned. Poor site selection, ineffective methods, and poor management are other problems limiting the use of existing ponds.

VI. POND HARVESTS

A. Marine Shrimp

Mexican growers are rapidly increasing pond harvests and emerging as major Latin American producers. Mexico reported less successful results during the 1980s than some other Latin American countries that are developing shrimp culture industries. The primary reason appears to have been the legal restrictions on private investors, although not all observers concur with this assessment. With the easing of these restrictions beginning in 1986, private growers began building ponds and reporting substantial progress in expanding cultured harvests (appendices D2 and E8).

1970s: Harvests were negligible during the 1970s. Efforts were mostly limited to cooperative/*ejido* projects, which primarily attempted various esturine-enclosure or primitive extensive operations.

1980-85: During the early 1980s, harvests continued at negligible levels. SEPESCA's efforts to promote a shrimp culture industry primarily focused on assisting cooperatives. These efforts, however, yielded disappointing results. (See Section VIII. Government Promotional Role.) After nearly a decade of effort and substantial Government assistance, Mexico's cooperative growers only harvested a negligible 100 t in 1985 (appendices D2 and E7).

1986-89: The Government's decision to modify the law reserving shrimp culture solely to cooperatives in 1986 enabled a few private investors to enter the industry for the first time. The entry of these energetic private sector groups appears to have provided a substantial impetus to the industry's development. The private growers introduced managerial competence, technical expertise, and more adequate financing. As a result, growers have reported significant harvest increases each year since 1987. A substantial number of new farms were opened (appendix G2) and by 1987 the new growers reported an 800 t harvest, a larger increase than during the entire 1980-85 period. Additional substantial increases were reported during 1988 and 1989. An industry observer reported that the 1989 harvest totaled about 3,200 tons.[99] Most of this harvest comes from the Sinaloa farms.[100] While still small by world standards, the growing Mexican harvest meant that substantial numbers of farm managers, technicians, and workers for the first time were gaining practical experience in farm operations. This experience meant that the country was finally laying the foundation for a significant new industry. Growers reported increasing problems obtaining pl seedstock. While increasing numbers of Mexican nationals were gaining experience in growout operations, little progress was achieved in initiating a modern hatchery industry. Almost all seedstock was collected in the wild. A few hatcheries were opened, but reported only limited runs and hatchery pl production was negligible.

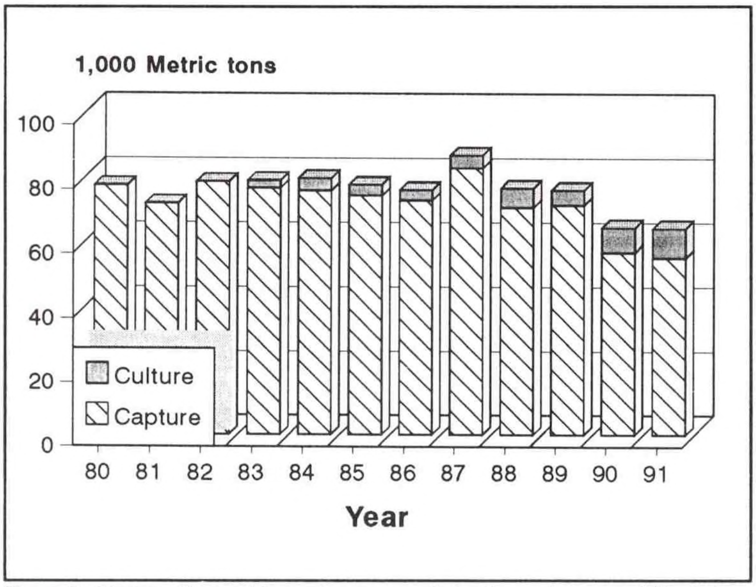


Figure 5.--Mexico. Cultured harvests are a small, but increasing, part of Mexico's total shrimp harvests.

1990: Growers reported further substantial harvest increases in 1990, with cultured harvests claiming an increasing though small share of Mexico's total shrimp harvest (figure 5). Marine shrimp harvests exceeded 5,000 tons.[101] Growers reported that they could have achieved even larger increases, but that seedstock shortages impeded full utilization of existing pond area.[102] Growers increased wild pl collections, but continued to report difficulty obtaining adequate postlarvae. Hatchery operators reported a variety of technical problems. (See Section XIV. Postlarval Supply.) Despite these problems, Mexican growers still managed to achieve considerable success, increasing harvests by more than 50 percent.

1991: Growers and Government officials continued to report expanding harvests. The newly-appointed Secretary of Fisheries, Guillermo Jimenez Morales, projected a 1991 harvest approaching 7,000 t,[103] an impressive increase of nearly 50 percent. This makes Mexico the third leading producer of cultured shrimp in Latin America (appendix E4). The expanding pond area has significantly increased pl demand. Growers have continued to expand pl collection, but some continue to report problems obtaining adequate pl and arranging for timely delivery. Continuing problems in collecting wild pl have made the need for hatcheries increasingly apparent. The seasonal availability of wild pl in particular appears to limit full utilization of ponds, and as a result impairs yields. Several new hatcheries were opened during 1991. While a few reported successful production runs, most reported serious operating difficulties.

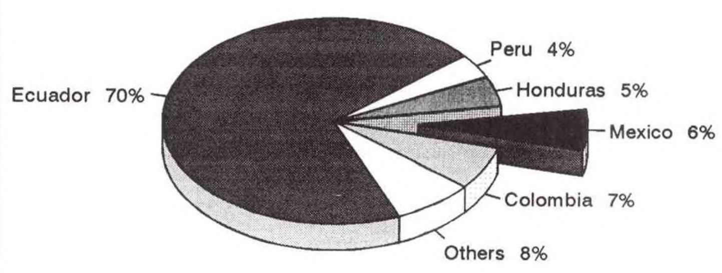


Figure 6.--Latin America. Although Mexico has increased harvests in recent years, Ecuador remains the dominant producer of cultured shrimp in Latin America.

1992: A few hatcheries are finally reporting sustained success with producing postlarvae. In additon, SEPESCA appears to be making some progress in improving the system of collecting wild postlarvae. (See XIV. Postlarval Supply.) New farms opened in 1991 and improved operations of existing farms should permit another substantial harvest increase in 1992 to over 9,000 tons. Some observers even estimate that the 1992 harvest may reach 10,000 tons.

1990s: Mexican growers appear poised to substantially increase cultured harvests during the 1990s. The opening of the industry to private investors is clearly having a major impact. During 1990-92 growers increased harvests about 50 percent annually. They should be able to steadily expand pond area during the rest of the decade. While the annual rate of harvest increases will probably moderate, growers will almost certainly achieve very major increases. Most observers are projecting that Mexican growers should be able to harvest at least 25,000 t by the year 2000 and some are optimistically predicting even larger increases. Some observers, however, express concern that a variety of problems (especially collecting wild pl and initiating significant hatchery production, constructing ponds, producing adequate feeds, and financing) will impair growers' ability to achieve their more optimistic projections.

Mexico is now emerging as a regional leader in shrimp culture. The Latin American shrimp culture industry during the 1980s was dominated by Ecuador and other countries harvested only minor amounts (figure 6).[104] In the past few years, however, several countries have begun to expand cultured harvests, notably Colombia, Honduras, and Mexico (appendix E4). Many observers believe that Mexico and several other countries will become major participants in the region's shrimp culture industry during the 1990's.

B. Freshwater Shrimp

Mexico also produces freshwater shrimp (appendices E5 and E8-12). The authors have been able to obtain little information on the freshwater culture industry. Some information is available on various feasibility studies to assess potential commercial operations.[105] Few accounts exist, however, on actual freshwater farms and harvests. Available data should be used with some caution as Mexican statistics sometimes combine freshwater aquaculture with freshwater capture fisheries.[106] In addition, the authors cannot account for major statistical fluctuations reported in official data.

1970-75: SEPESCA reports that growers substantially increased harvests of freshwater shrimp during the early 1970s, possibly a reflection of the interest in shrimp aquaculture and Government promotional efforts.[107] Many observers were optimistic that freshwater shrimp would prove to be an important commercial crop. By 1975, freshwater shrimp harvests reportedly reached 1,000 tons. Unlike marine shrimp, private investors were permitted to culture freshwater species. Early growers, however, did not achieve the results projected. As a result, few private investors committed funds.

1976-82: The late 1970s and early 1980s saw freshwater harvests decline to almost negligible levels. Harvests rarely exceeded 100 tons. The authors have not been able to obtain information to confirm or explain this decline.

1983-88: Freshwater harvests increased sharply beginning in 1983. Growers set new records in 1983 (2,300 t) and 1984 (3,800 t). The harvest decreased in 1985 and 1986, but still overshadowed the meager marine harvests (appendix E8).[108] The authors have no information explaining these sharp fluctuations. Freshwater shrimp harvests continued to outpace marine harvests even as late as 1988, when the freshwater harvest reached 3,700 tons (appendix

E11).[109] Harvests of this magnitude made Mexico one of the pricipal producers of freshwater shrimp in Latin America.[110]

1989-91: Recent freshwater harvests appear to have slumped, reaching a low of about 1,500 t in 1989, and rebounding to about 2,500 t in 1990. It is likely that declining Government support is causing *ejidos* and cooperatives to close farms.

1990s: Significant harvest increases during the 1990s appear unlikely. Most potential private investors appear to have concluded that commercial prospects for marine culture outweigh the more limited potential for freshwater shrimp. Marketing difficulties and a variety of technical and economic problems are unresolved. The lack of uniformity in the harvested shrimp, low meat yields, and poorly developed markets are all serious obstacles.

VII. LEGAL AND SOCIAL FRAMEWORK

Mexico has long considered shrimp to be an important national resource. The Government for years reserved shrimp and other valuable marine species to fishery cooperatives.[111] Not only did the Government reserve shrimp fishing to the cooperatives, but it also reserved the culture of marine shrimp. Many observers now believe, however, that the Government's support for the cooperatives has not proven beneficial to the industry or economy as a whole. The Government assisted the cooperatives for years and in 1981-82 helped them to acquire all privately-owned shrimp trawlers This enabled the cooperatives to totally control all aspects of shrimp harvesting in Mexico. Cooperative management of the shrimp fishery, however, has proven disappointing, both in the capture fishery and on the farms. The cooperative fleet has deteriorated and declined in numbers, and their catches have fallen.[112] Even the earnings of individual cooperative members have declined. Despite continued Government financial support, the cooperatives report mounting losses.[113] SEPESCA Coordinador de Delegaciones Foraneas, Juan Jose Moreno Sada, estimates that only about half of the nearly 2,000 fishery cooperatives are operating adequately.[114] Even cooperative officials are concerned with the current state of their movement. The President of the Fisheries Section of the Confederacíon Cooperativa, Francisco Mandoza Reyna, estimates that as many as 25 percent of the country's fishery cooperatives engage in "irregular" activities.[115]

The cooperatives' disappointing accomplishments after three decades of effort suggested to many observers that they are incapable of profitably managing the capture shrimp fishery.[116] The cooperatives' experience with shrimp culture is even more bleak. The cooperatives have clearly failed to develop the country's potential to be an important producer of cultured shrimp. Despite receiving the exclusive right to culture shrimp, very few cooperatives were able to achieve even limited commercial success.

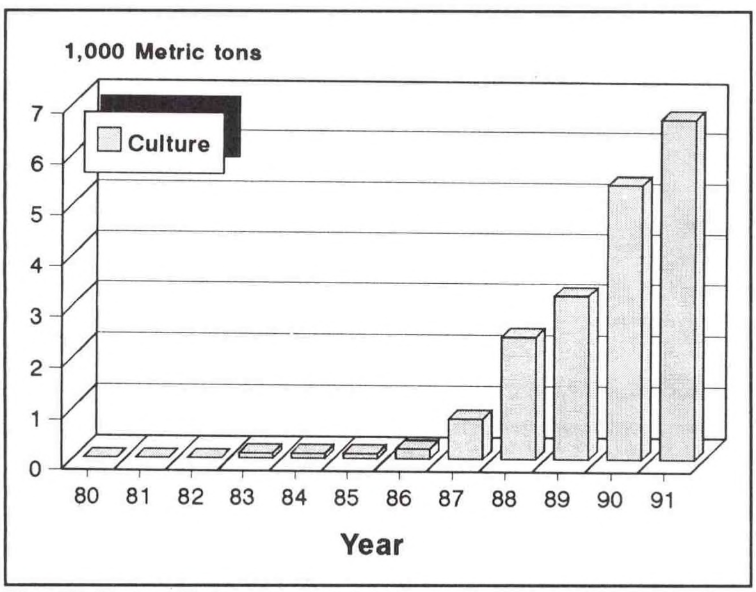


Figure 7.--Mexico. Marine cultured shrimp harvests have increased dramatically since the Government began a series of legal and regulatory reforms.

The Government in a major policy reversal beginning in 1986 decided to permit limited private investment in the industry.[117] The resulting increase in culured harvests has been impressive (figure 7). A series of Government decisions has since steadily expanded the role for private investors in the country's shrimp industry. The Government's measures have already been extensive, but new legislation proposed by President Salinas in 1992 may introduce a shaply revised management system for Mexican fisheries. One of the key proposals is the termination of the cooperatives' exclusive right to harvest shrimp and other reserved species. The President has stated that the shrimp industry should not be the exclusive domain of the cooperatives, but rather should be conducted through a

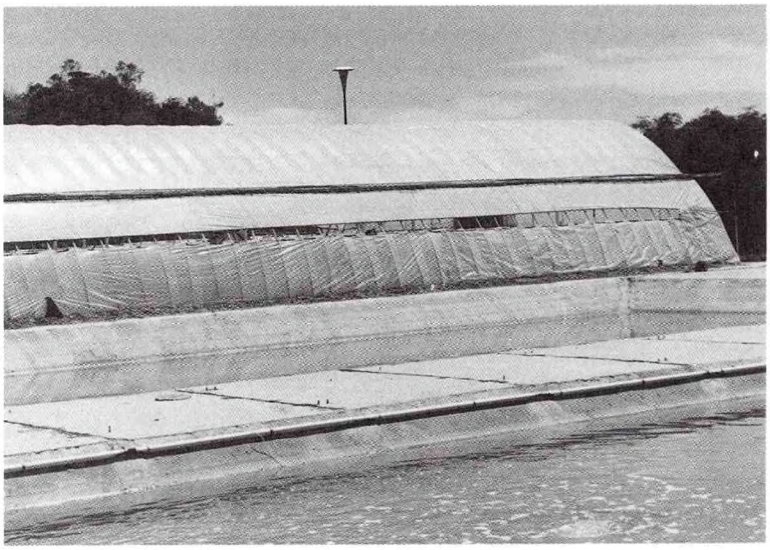


***Photo 6.**--Mexico. The Government has assisted ejidos and cooperatives. This hatchery, was built at an ejido site. Dennis Weidner*

partnership of cooperative and private interests.[118] This shift has inevitably caused significant strains.[119] Despite the difficulties, however, Mexico is clearly making considerable progress in developing the appropriate legal and social framework for developing its shrimp culture potential.[120]

A. Background

Government and industry observers generally agree that the legal framework regulating shrimp culture has been a major impediment to the industry's development since the 1970s.[121] The 1972 *Ley Federal de Pesca*[122] reserved the country's shrimp resources, as well as several other valuable species, to the "social sector" -- traditional fishery cooperatives and *ejidos*.[123] The law was interpreted as applying not only to shrimp fishing, but to marine shrimp culture as well.[124] This interpretation prohibited private investment, and thus severely restricted the availability of both investment capital and managerial talent to the industry. The exclusion of private foreign investors had the unintended effect of impeding the flow of advanced foreign technology, restricting the access of Mexican shrimp farmers and researchers to the major advances being made in growout and hatchery technologies. (See Section XI. Methods/Yields and Section XIII. Research.) These factors, together with the overall credit crunch beginning in 1982, largely explain Mexico's failure to develop its very significant potential to culture shrimp.

The social sector (both cooperatives and *ejidos*) held the exclusive concession for culture shrimp, but lacked the technical capability and necessary resources to develop the industry on its own. Mexican cooperatives have for years participated in Latin America's largest shrimp trawl fishery, and from 1982 to 1990 operated all of the country's shrimp trawlers. The *ejidos* hold title to much of the coastal land suitable for shrimp culture in Mexico. *Ejiditarios* have conducted artisanal shrimp fisheries in coastal estuaries. Both groups, however, have limited managerial capacity, poor access to credit, almost no members with technical training, and few opportunities or little desire to acquire needed outside assistance. The Government attempted to remedy these limitations with technical assistance and some limited credits.

Management: While some cooperatives and *ejidos* may be capable of managing shrimp farms, most have experienced considerable difficulties.[125] The *ejidos* are located in rural coastal areas, isolated from commercial and educational opportunities, and most lack the expertise required to successfully manage sophisticated operations like commercial shrimp farms.[126] Most ejiditarios have only minimal primary educations. While the cooperatives are often located at principle ports, few members have any advanced education. Most observers point to the lack of managerial competence as one of the cooperatives' weakest attributes.

Credit: Both cooperatives and *ejidos* have significant credit problems. Shrimp cooperatives, many of which are already heavily indebted and generally considered poor credit risks, have limited access to credit.[127] Commercial banks have historically been hesitant to lend to cooperatives, a situation made worse by the 1990 demise of the Government fisheries development bank, the Banco Nacional Pesquero (BANPESCA). *Ejidos* hold their land in perpetuity as a result of Government land grants, and were constitutionally prohibited from selling their land or using it as collateral to obtain loans.[128] This greatly reduced their access to the capital necessary for building shrimp farms. The Mexican Government has recently modified the legal basis of the *ejidos*, thus permitting private ownership by individual *ejido* members of *ejidal* lands. Mexican officials report that successful operating *ejidos* will continue to operate, but those *ejidos* experiencing serious problems may be broken up. These changes have the potential to significantly improve the ability of some *ejidos* to obtain credit.[129]

Technology: Access to the sophisticated aquaculture technology and expertise has been an on-going concern for the cooperatives and *ejidos*. Mexican laws intended to protect cooperative and *ejidal* control of shrimp culture has restricted their ability to form joint-ventures or sign management contracts with private businesses (both domestic and foreign groups). The absence of private firms has had the unintended effect of limiting access to technical expertise, equipment, and advanced research. While the Government is relaxing many of these barriers, some restraints still exist. The problem was exacerbated by the minimal education and suspicious attitude of many *ejido* members toward outsiders. The lack of appreciation for the need to acquire technical assistance was an additional problem.

Some industry observers are convinced that cooperatives and *ejidos* are not suited for shrimp farming. Mexican fishery cooperatives were hesitant to culture shrimp, as many initially viewed shrimp culture as a threat rather than an opportunity.[130] Shrimp farming requires different work habits and approaches than capture fishing. Farming means that a cooperative has to carefully nurture a crop over a period of time. In contrast, the fishermen are accustomed to working only a part of the year when they engage in short trips of intense effort, sharing a naturally-occurring common property resource. Shrimp farming requires a major shift of mind set, affecting both the fisherman's lifestyle and job skills. It was probably unrealistic to expect fishermen to quickly or easily adapt to the sedentary life and new skills associated with sophisticated commercial aquaculture. Shrimp culture is also a fairly high-risk enterprise, especially in Mexico, where no established shrimp culture industry exists to provide models for potential farmers. The high risks and potentially high returns seem to demand an entrepreneurial spirit not previously displayed by the financially strapped fishery cooperatives and the communal *ejido* societies.

B. 1986 Legal Revisions

The failure of Mexico's social sector to significantly develop shrimp culture was becoming increasing apparent by the mid-1980s.[131] Shrimp harvests provided a major source of export revenue for Mexico, but the country's small cultured harvests contributed little to these earnings. Further, Mexico's market share in the key U.S. market deteriorated badly during the 1980s (appendix K7). By contrast, the country's principle competitor (Ecuador) tripled its cultured harvests between 1980 and 1985, a trend mirrored in world-wide shrimp culture production (appendices E1-2 and E4). (See Section XVII. Marketing.) Mexico's shrimp cooperatives, in sharp contrast, reported minor efforts during the period to culture shrimp and achieved only marginal results. In addition, the country was locked in a financial crisis due to heavy foreign debt and the Government was able to provide only limited financial assistance to the cooperatives.

The Mexican Government first attempted to attract private investment without disrupting the fundamental tenant of reserving shrimp to the social sector. The administration of President De la Madrid in 1986 revised the *Ley Federal de Pesca*. The 1986 revisions sought to channel investment funds to the farms through a special trustfund.[132] It encouraged cooperation between the private and social sectors, while retaining the key provision reserving shrimp culture to cooperatives and *ejidos*.[133] In practice, the revised law allowed families, *ejidos*, and groups of private individuals to form special cooperatives to culture shrimp and other reserved species.[134] Private groups were thus able to enter the industry, albeit on a highly restricted basis, by obtaining a Government concession and cooperating with the traditional groups that still dominated the industry. Only a small number of special cooperatives, however, were successfully formed. The process of obtaining the necessary permits for a concession remained arduous and costly, on top of the normal uncertainties and risks of actually building and operating a shrimp farm. Most investors were understandably hesitant to commit substantial funds until there was a clearer statement by the Government on the future role of private investment.

The debate over the role of the private sector in the shrimp culture industry continued for several years. The issue was widely publicized in the national media. The Government's objectives were outlined in an executive-commissioned study released in 1988.[135] The study recommended a "pragmatic and practical" strategy of allowing private industry to "guide" the development of shrimp culture within guidelines established by the Government. Further political impetus was provided by the election of President Salinas in 1988, who initiated overall economic policies significantly expanding the role of the private sector. Broad agreement was eventually reached within the shrimp industry to permit an increased role for private investment. Most observers felt, however, that such a policy decision required further amendments to the *Ley Federal de Pesca* to make the obligations and rights of investors clear.

C. 1990 Legal Revisions

The Government revised the fisheries law again in December 1989.[136] One of the principal goals was to further encourage private investment in the culture of reserved species, especially shrimp.[137] The new law, which went into effect in April 1990, allowed SEPESCA to grant shrimp culture concessions directly to private individuals and groups with Mexican citizenship,[138] without the costly legal subterfuge of forming special cooperatives. Mexico's new Fisheries Minister, Secretary Jiminez, is clearly intent on attracting more private investment in shrimp culture and other sectors of the fishing industry.[139] The new law also allows foreign direct investment in shrimp culture, under the same 49 percent restriction that had applied to the rest of the Mexican economy.[140] Several foreign groups, including Taiwanese investors, **France Aquaculture**, and the U.S. company **Transpacific Seafood**,[141] have expressed interest in establishing joint ventures since the law was revised. The authors have only limited information on these ventures, however, and many more joint venture projects may have actually been established. Mexico's success in attracting foreign partners will significantly affect the industry's ability to expand and overcome major constraints, such as problematic pl supply. Foreign investments, however, continue to be an emotionally charged issue in Mexico. (See Section IX. Foreign Participation.)

Industry observers regarded these revisions as a critical step in expanding participation by private investors. Some Mexican businessmen, however, initially complained that the terms and conditions under which shrimp farming concessions would be granted were poorly defined.[142] SEPESCA prepared regulations to implement the changes, but the politically sensitive issues involved delayed final decision and publication for over a year. SEPESCA finally published regulations implementing the December 1989 legal revisions in February 1991.[143] The full impact of these new regulations is, as of yet, not fully known. They do, however, emphasize the "combination of efforts of the public, social, and private sectors in the cultivation of reserved species." The regulations appear for the first time to open the culture of shrimp to anyone with the necessary know-how, resources, and land.[144]

The regulations radically changed the role of the cooperatives. While no longer reserving them the exclusive right to culture shrimp, these regulations nonetheless guaranteed an important role for the cooperatives. The Government granted the cooperatives the exclusive right to supply wild seedstock, by collecting both pl and berried females. SEPESCA foresaw the cooperatives developing an artisanal pl collection effort, as had occurred in Ecuador, Panama, Peru, and some other Latin American countries.[145] The ability of Mexican cooperatives to efficiently initiate and manage a major pl collection effort, however, is yet to be demonstrated. Initial efforts are not encouraging. Given the absence of significant hatchery pl production, the efficient collection of wild seedstock is currently a critical element in the operation of many farms. Postlarvae supply problems are already impairing some operations and could threaten the industry's continued expansion. (See Section XIV. Postlarval Supply.)

D. Current Situation

The Mexican Government has addressed many of the most significant legal problems which have impaired the development of the country's shrimp culture industry. The entry of private investors is having a major impact because of the technical expertise and investment capital that it has brought to the industry. It is also attracting increased numbers of talented, aggressive entrepreneurs. The industry's expansion has been impressive in both 1990 and 1991, and appears to be continuing in 1992. (See Section VI. Pond Harvests.) One press report at the end of 1991 announced eight new shrimp culture projects in Sinaloa with investments totaling $60 million.[146] In addition, opening the industry to foreign investment will help provide not only needed credit, but also access to the most recent technical developments in shrimp culture research.

Despite the Mexican Government's progressive opening of the shrimp culture industry to private investment, some observers believe that excessive Government regulation continues to stifle the industry's growth. SEPESCA's Director General of Aquaculture in 1989 told one of the authors that he preferred the Mexican approach of "slow careful planning" to the "haphazard" development of the Ecuadorean industry. Critics contend, however, that the Government's "careful planning" has generally hindered, rather than promoted, the industry's development. Government officials insist that careful regulation of the industry is important, and cite a variety of environmental concerns. (See Section IV. Growing Conditions.)

Industry groups are concerned over SEPESCA's regulatory role. Many report past problems with SEPESCA regulatory efforts. If difficulties obtaining pl increase, growers will intensify criticism of SEPESCA's tight restrictions on pl collection, transport, and import.[147] Growers have been required to obtain Government approval for virtually every aspect of their operations. Permits were needed both to harvest ponds and to market the product once harvested. Obtaining the permits is a time consuming process, and reduces the growers' ability to adjust operations to changing technical requirements and market conditions.[148]

SEPESCA has acknowledged that excessive permit requirements impede the industry's development.[149] The new regulations appear to eliminate the need for a permit to open a farm on non-Government lands and reduce the number of permits necessary to operate a farm.[150] Growers are hopeful that these changes will lighten their regulatory burden. They report, however, that there is often a lag between new regulations and enforcement by local officials. Despite the new regulations, SEPESCA's role remains significant.

E. Additional Steps

Successive Mexican governments have for years subsidized the country's cooperative movement, but the Salinas Administration is taking an increasingly pragmatic position. President Salinas himself has recently criticized the debt-ridden cooperative movement.[151] Large numbers of cooperatives report serious financial problems. Cooperative leader José Luis Castro Verduzco admits that many cooperatives are at the point of closing, while others are being restructured.[152] The Government has taken several steps to restructure the industry. The most significant new policy is allowing the private sector to re-enter the shrimp industry in a limited manner. Other steps are currently in progress or under consideration. Most important among these is a proposed constitutional amendment President Salinas sent to Congress on November 6, 1991, and approved in early 1992. The amendment allows individual *ejiditarios* the option of privatizing their lands.[153] This option could open much of the *ejido*-owned land suitable for shrimp culture to private investment.[154] President Salinas also submited legislation in April 1992 that would cancel many of the cooperatives' specialized privileges, including reserved status for shrimp that cooperatives and *ejidos* have held for many years.[155] The proposed legislation would replace the reserved species regime with a new Individually Transferable Quota (ITQ) system. The Salinas Administration is also seeking to simplify most SEPESCA procedures to obtain permits, concessions and other authorizations. Several provisions are designed to make investment (both domestic and foreign) far more attractive than before by de-regulating the time-consuming application process for aquaculture on private lands, and by providing aquaculture concessions, depending on the amount invested, for up to 50 years.[156]

Some observers have been extremely critical of Mexican Government efforts to promote a shrimp culture industry. Some criticisms of SEPESCA are somewhat unfair. The agency has overseen fundamental changes in both law and policy, as well as the massive expansion of the shrimp culture industry in only a few years. The fundamental factors which previously impeded the industry's development, such as the legal restrictions on private investment, were largely beyond SEPESCA's control and reflected deep-seated, established Mexican Government policy. Changing these policies required fundamental economic policy changes by the President. Some local observers, however, insist that some criticism of the agency is valid, especially of the restrictive regulatory regime. The most recent revisions to the fisheries law appear to directly address this concern, though their exact impact is yet to be seen.

VIII. GOVERNMENT PROMOTIONAL ROLE

The Mexican Government has promoted the development of one of the largest aquaculture industries in Latin America.[157] The principle focus of Mexico's aquaculture policy through the 1970s was to increase harvests of low-cost species to expand domestic food supplies. (See Section II. Aquaculture Industry.) The Government decided in 1985 to give priority to shrimp culture, as part of a larger effort to increase foreign exchange earnings.[158] Mexico's declining market share in the U.S. shrimp market and falling real export earnings during the 1980s have been the driving force behind the Government's decision to promote a shrimp culture industry.[159] Despite the Government's promotional efforts, the legal impediment to private investors restricted the industry's development during much of the 1980s. Observers are now convinced that the 1986 and 1989 modifications of the law regulating shrimp culture have provided a major boost to the industry's development. (See Section VII. Legal and Social

Framework.)

The Government in 1987 announced the centerpiece of its effort to promote shrimp culture. The *Programa Nacional de Cultivo de Camaron* (PNCC) was a massive 7-year program. The PNCC was designed to create a major shrimp culture industry by 1994 and called for the construction of over 70,000 ha of ponds, capable of producing 61,000 t of shrimp annually by 1994. SEPESCA originally projected a 1990 harvest of over 20,000 tons. The plan was the most ambitious ever conceived by a Latin American country. Many observers viewed it, however, as overly optimistic. Aside from the time, expertise, and investment capital required to build the ponds, such a massive expansion program would need large numbers of qualified technicians to manage the new operations. The pl and feed supplies problems would also each require a major effort to resolve. The Government has been unable, to date, to make the financial commitment necessary to achieve such ambitious goals, let alone the major effort needed to execute the needed research and training program required. Even if massive Government financing had been available, it is questionable if Mexico had adequate technicians and construction capabilities to meet its objectives in such a short period of time.

The PNCC as a result remains a set of optimistic goals for the industry, rather than realistic objectives. The 1990 harvest did not reach 6,000 t, much less the 20,000 t projected in the PNCC. A harvest of 20,000 t, however, even if achieved in 1994, would be a remarkable achievement. A massive expansion of the industry on the scale envisioned by the PNCC required either costly Government subsidies and other incentives, or a massive infusion of private capital into the industry. The financially strapped Mexican Government has simply been unable to provide the credits and other incentives needed to reach the established targets. Nor is it the policy of the current Administration to subsidize industries as previous administrations have done. The progressive opening of the shrimp culture industry to the private sector is providing an alternative to Government credits, as private investors are able to raise their own funds through commercial banks. Some Government foundations provide limited credit and loan guarantees, such as the Fidicomiso Instituto en Relación de Agricultura (FIRA). Given the traditional skepticism which banks have shown toward aquaculture in general, and shrimp culture in particular, the reliance on private financing is resulting in a much more gradual expansion than that laid out in the PNCC. In the long run, this slower but more careful expansion program may prove to be a more effective approach. Industry sources are hopeful that the credit situation will improve now that they can point to increasingly successful commercial operations.

A more realistic role for the Government has been laid out as part of the *Plan Nacional de Desarrollo 1989-1994*. The topics identified address many of the most daunting concerns to the developing shrimp culture industry: climatic conditions, seedstock and feed availability, land ownership, and infrastructure development.[160] This strategy for shrimp culture development indicates that the Government has identified some of the most important issues. It remains to be seen if these problems are being effectively addressed.

IX. FOREIGN PARTICIPATION

Foreign involvement in the Mexican shrimp culture industry has been severely limited, primarily as the result of past restrictions on private investment. All private investment until 1986 was prohibited, and foreign participation is still limited to a 49 percent share.[161] (See Section VII. Legal and Social Framework.) Cooperative growers also exhibited little interest in seeking foreign technical assistance. Foreign consulting groups limited efforts to enter the Mexican market because of the weak financial state of the cooperatives and difficulties in doing business with them. The earliest foreign participation was through joint research agreements between U.S. and Mexican university groups. More recently, the Government has contracted consulting firms to help assess potential shrimp culture sites. With the introduction of private investment following legal changes in 1986 and 1989, there has been much interest on the part of Mexican investors in obtaining foreign technical assistance and investment capital. Foreign consulting interests are now assessing possible Mexican operations and a few have already signed contracts with growers and hatcheries. Such consulting contracts are likely to increase substantially during the 1990s as Mexican farms address a wide variety of technical problems. Some observers believe that Mexico will require significant foreign assistance to address one especially difficult technical problem, producing pl seedstock in hatcheries.

Only limited information is available on foreign groups participating in the Mexican shrimp culture industry:

Ecuador: The authors have received reports that several Ecuadorean investors and consulting groups are interested in expanding operations to Mexico. One observer identified the group **El Camarón Dorado** as planning to invest $700,000 to build a hatchery, to be followed by a 70-ha shrimp farm.[162] **Panaeid Tecnologia Internacional** (PENTEC), a consulting firm which provides technical assistance to farms in Ecuador, is also looking for potential Mexican clients.[163]

France: SEPESCA has contracted France Aquaculture (FA) since 1989. FA's primary activities have centered around regional assessments of potential shrimp culture sites, such as in the state of Chiapas.[164] FA and SEPESCA have also cooperated to produce a number of technical manuals intended to assist growers in constructing and operating ponds.[165] FA has contracted with at least one private farm (**Cultivaciones Mar de Cortez**) to provide technical assistance. (See Section X. Farms and Farms Ownership.) **Sanofi Aquaculture**, an FA affiliate, announced a major contract in 1991 with NOVUM (a private Mexican company with investments in shrimp culture), and Banamex, (Mexico's largest bank). The joint venture will encompass three major activities: to license **Aquatechnologia** to market FA's shrimp culture technology, to construct growout farms, and to develop hatcheries to produce pl for the joint venture and for sale to other farms.[166] (For details on specific projects, see Sections X. Farms and Farm Ownership, XIV. Postlarval Supply, and XV. Feed.)

Japan: At least one lab, the Centro de Estudios Tecnologicos del Mar, reportedly received funding and technical assistance for hatchery research from Japan. (See Section XVI.B. Hatcheries)

Panama: An unidentified Panamanian company is reportedly providing technical assistance to build the El Tambor hatchery in Culiacán, Sinaloa.[167] (See Section XIV. Postlarval Supply.) **CANASA**, a Mexican trans-national company also involved with shrimp culture in Panama, reportedly considered building a farm in Yucatán in 1988,[168] though the authors have no additional information.

Taiwan: The authors have received unconfirmed reports that investors from **Taiwan** have considered investing in Mexico. One observer reports that a Taiwan group is planning to invest some $7 million to build seven hatcheries in Sinaloa, Nayarit, and Oaxaca[169]. No further details, however, are currently available.

Thailand: The Mexican government recently signed a trade agreement intended to promote bilateral trade and to increase Thai investment in Mexico. The Thai **Charoen Pokphan** Group, a major shrimp grower, has expressed interest in Mexico's fishing industry, though the authors do not have any further details.[170] One observer reports a Thai-Mexican joint-venture is planning to invest $7 million in several hatcheries.[171]

United States: Early involvement by U.S. university groups focused on developing and testing growout methods for *P. stylirostris*. The major research project was conducted by the University of Sonora (UAS) and University of Arizona (UA), funded in part by Coca-Cola during the early 1980s. The project did not result in a full-scale commercial operation because of Mexican legal restrictions on private investment in shrimp culture. These restrictions prevented other groups from participating in shrimp culture for a number of years following the break-up of the UAS/UA project. Since legal changes in 1986 and 1989 have opened the industry to private involvement, several U.S. companies have begun looking at possible investments. **Transpacific Seafoods** has reportedly considered a major investment, though the authors have no additional details. **Aquafauna Bio-Marine** has reported major involvement in Mexico's hatchery program. Cornelius Mock has also reported some work in northern Mexico.

X. FARMS AND FARM OWNERSHIP

The number of Mexican growers has increased substantially in recent years. Available reports on farms and farm ownership suggest that in 1990 there were about 130 shrimp farms in Mexico, although sources vary somewhat as to the precise number (appendices G1-3). One local observer indicated that 105 shrimp farms were active in 1990.[172] Many of these farms, however, report only marginal harvests. Most of the inactive farms were those owned by *ejidos* and cooperatives, which have experienced technical problems, financial difficulties, and generally poor results.[173] All observers report that most of the farms are in the Pacific-coast state of Sinaloa. SEPESCA listed 98 farms as either in operation or under construction in Sinaloa by 1990.[174] Cooperatives and *ejidos* continue to own large

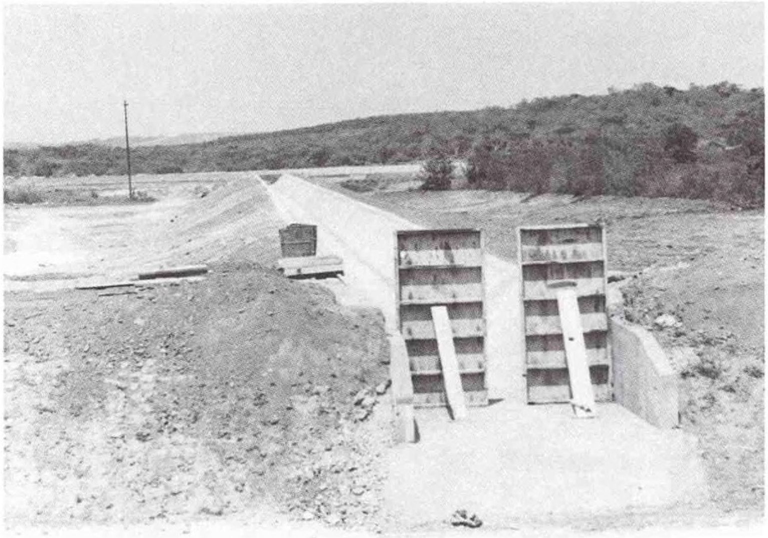


Photo 7.--Mexico. Most of Mexico's shrimp ponds have been built in the Pacific-coast state of Sinaloa. Dennis Weidner

numbers of farms. SEPESCA reports that in 1990 cooperatives owned 33 farms and *ejidos* owned 62 farms (appendix G3). The number of cooperative farms may include a number of "special cooperatives" established by private individuals under the revised 1986 law. Private investors directly operated only 37 farms, but these apparently include the most successful ones accounting for the bulk of the country's expanding harvest.

A. Marine

Mexican growers have focused on marine species, particularly *P. vannamei* and to a lesser extent *P. stylirostris*. (See Section II. Species.) Data on specific farms have proven difficult to obtain. Few growers appear willing to provide details on their operations. SEPESCA has compiled only limited information on farms throughout Mexico (appendices A3 and G1-3 and G7-11). Available information on selected individual farms follows:

Acuacultores de la Peninsula de Baja California: This cooperative, opened in 1989, claims to operate one of Mexico's most efficient farms in addition to a commercial hatchery. (See Section XIV.B. Hatcheries.) The farm has only about 10 ha of grow-out ponds, but reportedly harvested 50 t of *P. vannamei* in 1991 as of early November. Farm managers expected to harvest an additional 30 t by the end of 1991, for an impressive yield of nearly 8 t per hectare.[175] The authors have no independent confirmation of such a high yield.

Acuacultores del Norte de Sinaloa: This semi-intensive operation is located in Sinaloa. It was Mexico's first commercial operation when it opened in 1984 and is now one of the largest operating Mexican shrimp farms. The farm reportedly had 270 ha of active ponds from which about 240 t of marine shrimp was harvested in 1988, an average yield of nearly 1.0 t per hectare.[176] Local observers report both good technical and financial results.[177]

Acuacultura en Avance: This cooperative currently operates 56 ha of ponds, with land for some 200 ha of additional ponds.[178] The farm is located in Paredones, Sinaloa. Farm managers report using "intensive" methods.[179] The authors have no information on farm facilities or the growout system. The farm has no government concession.[180]

Aquacop: This cooperative operates 56 ha of "intensive" ponds at El Colorado, Sinaloa.[181] The authors have no additional information.

Aquanova: The joint-venture formed by Banamex, FA and NOVUM has constructed a 100-ha farm in southern Sinaloa.[182] The authors have been unable to obtain details of start-up operations. The company plans another farm in the north of the state, with technical assistance and sales offices in Mazatlán.

Biotac: This private operation located in Sinaloa constructed 70 ha of semi-intensive ponds by 1989.[183] Information on grow-out operations is not available, though the company does manage one of Mexico's most successful shrimp hatcheries. (See Section XIV.B. Hatcheries.)

Biotecmar: This private company operated a pilot project in Sinaloa with just over 1 ha of ponds in 1988. Utilizing intensive methods, the company claimed annual yields of 5 t per hectare.[184] The owner reportedly planned to expand to 40 ha and optimistically projected extremely high yields, 20 t per hectare. Such a high yield would obviously be a major achievement. The authors have been unable to obtain any additional or more recent information on the farm.

Camaronicultores de Sinaloa: This company operates about 190 ha of ponds, utilizing *P. vannamei*.

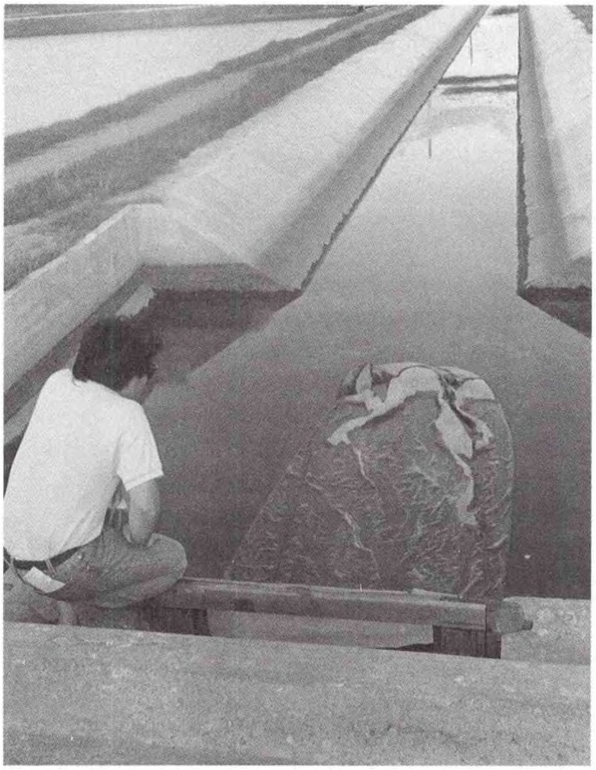


Photo 8.--Mexico. Water delivery systems at Sistemas Acuaticos Controlados near Escuinapa, Sinaloa. © *Leland Lai, Aquafauna Bio-Marine*

Company representatives reported three harvests per year, though the authors do not have additional details. The farm also operates a hatchery to supply its own seedstock and for sale to the many other shrimp farms in the area.[185]

Cultivaciones Acuícolas Mar de Cortez: The Mazon Family is expanding from 20 ha to a planned 150-ha farm on the Sonora coast north of Guaymas. This is one of the most northerly located Mexican farms and is thus a commercial test for the economics of culturing shrimp along the northern coast. The farm consists of 41 growout ponds and a small hatchery, and is being operated with technical assistance from France Aquaculture on a contract basis. The authors have no data on harvests from the farm, though plans called for production to begin in 1991.[186] Company officials reported a profit in early 1992, but no data are yet available.[187]

Ejidal Estero de Ponce: An extensive operation with some 240 ha of enclosed estuarine area, this *ejidal* farm had an average yield of only 0.1 t per ha in 1988.[188] More recent information is not available.

Ejidatarios Unidos de la Brecha: This ejidal farm has 115 ha of ponds and sufficient land for some 300 additional ha of ponds.[189] The semi-intensive farm is located in la Brecha, Sinaloa.

El Aparecido: A cooperative has reportedly opened a 50 ha farm utilizing intensive methods at Bahía de Navachiste, Sinaloa.[190] The farm reportedly has sufficient land to build 325 ha of ponds. The authors have no detailed information on the farm, though it is probably a semi-intensive farm. The farm reportedly has no government concession.[191]

El Patague: This ejido initially constructed 320 ha of extensive ponds, and achieved yields of 0.1-0.2 t per ha in 1988. More recently, they have expanded to 360 ha, and attempted to shift to semi-intensive methods. Additional details are unavailable.[192]

Finca Camaronera de Ahome: This cooperative has 31 ha of ponds in production,[193] with plans to build up to 150 hectares.[194] Their semi-intensive farm is located along the Bahía de Ohuira in Sinaloa.

Granja Camaronera Ahome Acuícola: This private farm, located near Ahome in Sinaloa, currently has 18 ha of ponds which are reportedly being used for "intensive" operations.[195] The company has land for as much as 300 ha of ponds.[196]

Granja San Vicente: This farm is owned by Acuacultores del Norte. The company has opened a second farm at Higuera de Zaragoza. This San

Photo 9.--Mexico. "Sock" used to filter incoming water at a shrimp farm near Mazatlán. © *Humberto Villareal, CIBBCS*

***Photo 10.**--Mexico. Water distribution channel for an intensive shrimp farm near Mazatlan. © Humberto Villareal, CIBBCS*

Vicente farm currently has 77 ha of active ponds. Land exists to add more than 200 ha of additional ponds. Granja San Vicente is a semi-intensive farm, though the authors have no more detailed information.[197]

Grupo Genesis: This private company has reportedly been experimenting with intensive culture methods, in conjunction with the Centro de Investigaciones Científicas de la Universidad de Sonora (CICTUS),[198] at Puerto Peñasco, Sonora. The authors do not have additional information on the facilities in use or results achieved. The group may be utilizing facilities originally constructed under the joint Universidad de Sonora-University of Arizona project which ended in 1980. (See Section VII. Legal and Social Framework.)

Industrias Acuicolas del Golfo (IAGSA): This farm is located at Dzilam de Bravo in Yucatán.[199] Plans call for the construction of 177 ha of semi-intensive ponds. The first stage with 35 ha of ponds is about 80 percent completed. Construction was delayed in 1991 due to funding problems, but additional funds have been obtained through FIRA and the company hopes to have the first stage completed by the end of 1992. IAGSA hopes to culture *P. vannamei* and *P. stylirostris*. The company helped fund the CIUVESTAU study assessing conditions in Yucatán.[200]

Mar Land: This farm is located near Ahome, Sinaloa, and operated 18 ha of ponds in 1991, with plans for 20 ha in 1992. The manager reported 1991 harvests of 27 t, achieving a yield of 1.5 t per hectare. The farm stocked a total of 5 million wild pl in 1991, though the owners are considering purchasing some hatchery pl in 1992.[201]

Matacahui: This cooperative-owned farm has 240 ha of ponds located at Higuera de Zaragoza, Sinaloa, with land for an additional 160 hectares.[202] The authors have no detailed information on operations, though extensive methods are reportedly being utilized.

Playa Negra: This *ejido* extensive farm operates 170 ha of ponds and has the area for nearly 800 ha of ponds. It is located in Ahome, Sinaloa.[203]

Ramon Ahumada: This semi-intensive farm has 270 ha of ponds, with the area for nearly 600 ha of additional ponds. It is located near Guasave, Sinaloa.[204] The authors have received conflicting reports as to whether the operation is a cooperative-owned or private farm,[205] though it reportedly operates with a government concession.[206]

Sistemas Acuaticos Controlados: The company reported its first harvest in late 1989. The owners stocked a 1-ha aerated pond with wild pl in May/June 1989, and harvested 5.1 t of 24-gram shrimp (average weight) 5 months later.[207] This was the first reliable report available to the authors of a successful intensive shrimp culture operation in Mexico.

Sol de Fuego: This cooperative operates 150 ha of ponds utilizing semi-intensive methods. The farm, which reportedly has no additional area for expansion, is located near San Ignacio in Sinaloa.[208]

Vista Hermosa: This ejido operation in Tamaulipas uses semi-intensive methods for 36 ha of ponds. SEPESCA Chief Jiménez Morales visited the farm in November 1991, together with Tamaulipas Governor Villareal and the Secretary General of the Universidad Autónoma de Tamaulipas.[209]

Other farms: Large numbers of new farms have been built in Sinaloa, and smaller numbers in other Pacific coast states such as Nayarit. The authors have been able, however, to obtain little information on specific farms. A few farms have also been built along the Gulf of Mexico/Caribbean coast. The authors have received unconfirmed reports of a large farm in Yucatán with about 250 ha of ponds. Several farm projects are also reportedly planned for Quintana Roo.[210]

B. Freshwater

The authors have received conflicting information on freshwater shrimp culture. Little information is available on individual farms. The information which is available indicates that most appear to be very small operations. Harvests are generally quite small (appendices E5 and E8-12) and facilities limited.[211] SEPESCA has, however, consistently reported large cultured freshwater shrimp harvests. (See Section V. Pond Harvests.) The discrepancy may be result from the tendency in Mexico to report inland fisheries as aquaculture. The authors have no way of accurately differentiating between actual culture and capture harvests, and have used SEPESCA data as reported.

XI. METHODS/YIELDS

A. Methods

The methods currently employed by Mexican shrimp growers are similar to those employed elsewhere in Latin America. Early Mexican efforts, however, focused on marginally effective enclosures. The first actual ponds were not built until 1980, when Mexican groups noted the impressive success achieved in Ecuador with extensive ponds.[212] Many of Mexico's shrimp farms used extensive methods during the 1980s, in large part because of the smaller capital investment and more basic technical sophistication required. Many Mexican operations using the ponds built in the early 1980s continue to employ extensive methods. Beginning in the mid-1980s, however, the better-financed private growers entering the industry shifted to semi-intensive methods.[213] Observers note that more than half of current harvests are obtained by semi-intensive growers due to their superior yields.[214] A few farmers have also attempted intensive innovations. Many question the appropriateness of intensive methods, however, claiming that such projects do not take best advantage of Mexican conditions. The substantial capital costs and sophisticated technical demands associated with intensive operations have limited the number of such projects.

Estuarine enclosures: Shrimp cooperatives in 1972 began experimenting by enclosing estuarine areas in Sinaloa. The authors, however, have few details on these operations.

Extensive farms: Many Mexican farms are designed for extensive operations. One local source reports that about 70 percent of the farms, primarily the *ejido*/cooperative farms, continue to use extensive or so-called "semi-extensive" methods. Extensive farms generally use organic fertilizers (some use none), only naturally occurring seedstock, low stocking densities (1-3 pl per m^2), and very limited water exchange. There is no application of feed. Ponds are very large, often more than 30 hectares. One farm reported a pond exceeding 100 ha, but this may refer to an estuarine enclosure. Extensive growers generally achieve very low annual yields of between 0.1-0.3 t per hectare.[215]

Semi-extensive farms: One report identified an intermediate intensity of production as semi-extensive, perhaps to differentiate these operations from others which are essentially little more than enclosed estuaries. Managers at these farms use organic fertilizers, occasionally small amounts of feed, natural occurring seedstock supplemented with some collected in surrounding estuaries, slightly higher stocking densities (3-7 pl per m^2), predator control, and increased water exchange.[216] Ponds are still quite large, between 25-50 ha, and produce moderate yields between 0.3-0.5 t per hectare.[217]

Semi-intensive farms: Many of the new farms currently being built in Mexico are designed for semi-intensive operations. These operations require substantial amounts of additional inputs as compared to the extensive methods, and almost all are operated by the still limited number of private investors who have entered the industry since 1986. Substantial amounts of organic fertilizer as well as supplementary feeds are required to maintain the higher stocking densities (5-15 pl per square m^2). Semi-intensive farm managers maintain water exchange rates of at least 10 percent per day and report yields of about 0.7-1.2 t per hectare.[218]

Intensive farms: Mexican growers have only recently begun to consider intensive operations, and only a few farms have actually been opened.[219] One intensive farm in the Teacapán peninsula region of Sinaloa, **Sistemas Acuaticos Controlados**, reported its first harvest in late 1989. (See Section X. Farms and Farm Ownership.) Intensive operations generally stock at very high densities (over 15 pl per m^2), and

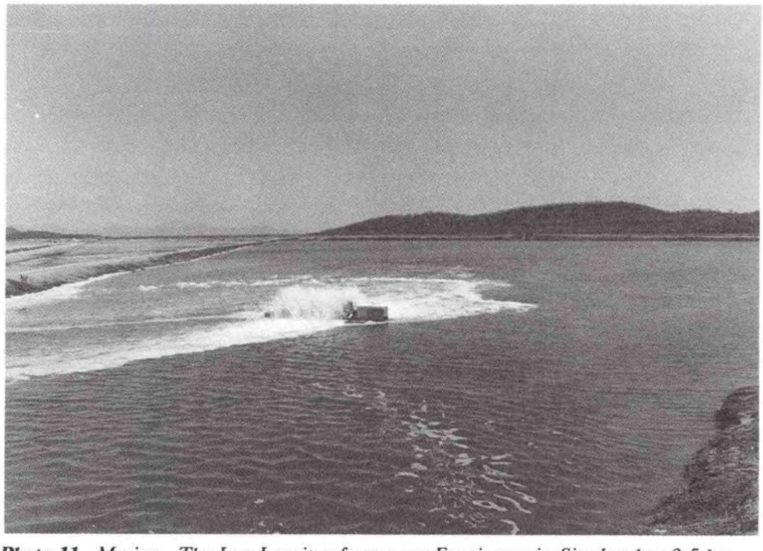


Photo 11.*--Mexico. The Las Lomitas farm near Escuinapa in Sinaloa has 2-5 ha ponds with 10 hp paddle wheel aerators. © Leland Lai, Aquafauna, Bio-Marine*

use small ponds (usually less than 4 ha) with careful regulation of water quality and an exchange rate of as much as 30 percent per day. A few Mexican companies using intensive methods have reported yields as high as 8 t per ha, though none have thus far consistently achieved such results for any length of time.[220] Caution should be used in evaluating Mexican reports as some growers refer to their essentially semi-intensive farms as intensive, to differentiate them from primitive extensive systems.

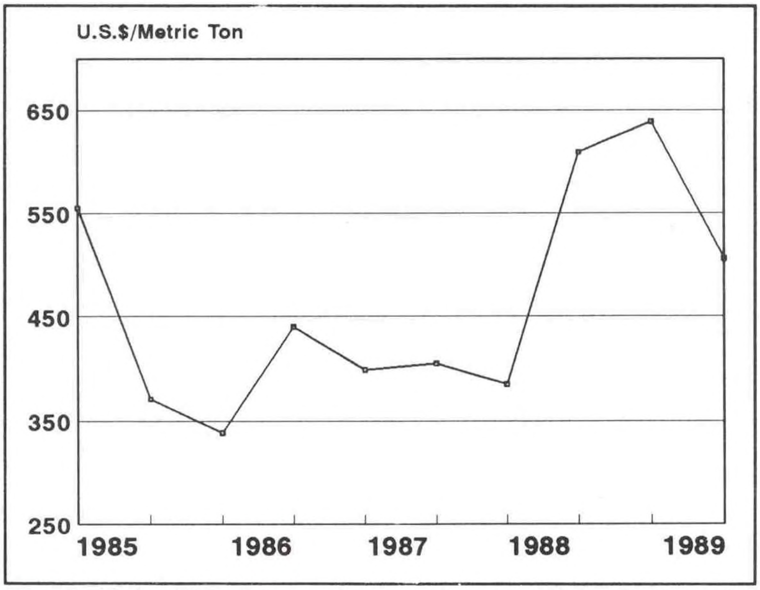


Figure 8.--Mexico. Rising fishmeal prices may reflect growers' increasing demand for the important shrimp feed ingredient.

B. Yields

The authors have only limited information on Mexican yields. Few growers release their yield data. Even estimating approximate overall yields is complicated by difficulties obtaining accurate data on the surface area of ponds actually in production. Rough approximations, however, suggest that Mexican growers are making some progress in improving yields (appendix D2), probably reflecting the increasing importance of semi-intensive methods.

Mexican growers report a wide range of yields. Most extensive and semi-intensive farms, for which the authors have obtained specific data, have reported relatively low yields (appendices G4-6). **Extensive** growers reported in 1988 yields ranging from 0.1-0.2 t per hectare. Some of the more successful extensive growers, operating semi-extensive farms, report better results of 0.3-0.5 t per hectare. **Semi-intensive** growers report an especially wide range of yields. Many report yields substantially below Latin American regional averages. Semi-intensive yields in 1988 ranged from 0.1-1.5 t per hectare.[221] Some growers as a result were forced to close their farms. The relatively low yields probably reflect the lack of experience among Mexican growers, especially those operating the new semi-intensive farms, and the limited training of farm managers. Even so, several semi-intensive growers had achieved yields of 1 t per ha or better. Industry observers reported in 1990 that the farms which managed to remain operational and stock their ponds are beginning to achieve dramatically improved results.[222] Some individual growers are reporting impressive yields, although the authors cannot substantiate these claims. (See Section X. Farms and Farm Ownership.) Available data on **intensive** farms are not adequate for valid yield estimates at this time.

XII. PRODUCTION COSTS

Mexico's competitive position is unclear. The country appears to have cost advantages in some areas, but disadvantages in others. The authors do not have sufficient data on which to base a detailed comparison with competing countries. Little data are available to the authors on the costs of constructing and operating a shrimp farm in Mexico. Many groups have made only limited efforts to maintain detailed records.[223] Some growers are independent and feel no need for detailed record keeping. Growers experiencing technical and financial difficulties often attempt to reduce costs by cutting back record keeping. Even farms keeping data appear unwilling to disclose sufficient data to permit accurate cost comparisons. Many are often unwilling to release accurate data for tax and competition reasons. Further, the limited available data often are not easily comparable because the bases and assumptions used in the compilations are not always clear or consistent.

Feed: The authors do not have broad pricing data for feeds in Mexico, though at least one Mexican feed concern noted that their feeds would sell at a slightly higher price than comparable products in the U.S. market, due to the higher Mexican prices for necessary ingredients such as fishmeal. Fishmeal, one major source of protein in shrimp feeds, has experienced a substantial price increase, particularly since 1988 (appendix H3). The increasing world demand for aquatic feeds, as a result of expanding aquaculture industries, could be partially responsible for the price increase (figure 8). Mexico will have to increase costly fishmeal imports for any significant production of shrimp feed. (See Section XV. Feed.)

Fuel: Fuel prices have been relatively low in Mexico, due to pricing policies of the national petroleum company, Petroleos Mexicanos (PEMEX). The current Mexican Government, however, as part of its broader economic policy, has increased fuel prices to better reflect international levels. As a result, growers have to contend with rising fuel costs. One observer notes that fuel expenses have begun to hamper efforts to intensify existing operations. The authors, however, do not have specific data to support this assertion.

Labor costs are generally comparable to other Latin American countries. Wages are particularly low in the rural coastal areas where unemployment is often a serious problem. The cost of attracting highly skilled and trained technicians to the rural areas would be high, though not more so than elsewhere in Latin America.

Land costs have not been a problem. The land situation, however, is complicated. Sizable portions of Mexico's coastal lands are owned by *ejidos* and until 1992 were not available for purchase. (See Section VII. Legal and Social Framework.) Some of these groups stand to benefit greatly from their lands. The 1992 constitutional change will allow *ejidos* to opt for privatization of land titles, greatly increasing the area of suitable land available for commercial development as shrimp farms and other projects.[224] If growers continue to build farms at the current rapid rate, the market value of such land may increase substantially, thereby driving up land costs. Some observers in the other countries have already noted this effect, especially in areas where farms are clustered together. Other concerns exist such as conflicting or unresolved land title problems.[225] In addition, SEPESCA and SEDUE may be reluctant to issue permits for the use of esturine areas.

Machinery and equipment have in the past been costly to growers, due to Mexico's tight import and foreign investment restrictions. Recent moves toward liberalization should increase access to technology and equipment from U.S. and other foreign sources. (See Section IX. Foreign Participation.)

Seedstock shortages have adversely affected some projects, driving up production costs. Worse still, many growers have been unable to obtain seedstock on a timely basis and in some cases have been unable to obtain it at all -- forcing them to leave ponds idle. The authors have been unable to obtain reliable data on pl prices. Unconfirmed reports suggest, however, that some growers' report relatively high pl costs.[226] The problem appears particularly pronounced with smaller, poorly financed farms that are not associated with hatchery projects.

One observer has attempted to estimate the relative construction and operating costs for extensive and semi-intensive operations in Mexico. While the authors do not have sufficient independent data to confirm these estimates, they are reportedly based on on-site surveys of farms in Sinaloa (appendix F3). As would be expected, these estimates indicate that semi-extensive farms are generally more expensive than extensive farms to build and operate. Semi-intensive growers report, however, lower production costs. Based on these estimates, the export cost of shrimp from extensive operations ranges from \$5.10-\$5.75 per kilogram. Semi-intensive growers achieve slightly better results, producing shrimp at between \$4.75 and \$5.45 per kilogram.[227] Growers report the best results at the larger farms (greater pond area) which benefit from economies of scale, enabling them to achieve the lowest production costs per hectare.[228]

Some observers believe that Mexican farms, especially those located in northern states (Baja California, Baja California Sur, Sonora and Tamaulipas) may report relatively high production costs because of less than ideal climatic conditions. Lower temperatures will restrict year-round use of extensive and semi-intensive grow-out facilities and impair lower growth rates. Other observers are hopeful, however, that high production costs in these states can be offset by their proximity to important export markets in the United States. Growers along Mexico's north Pacific coast, for example, are extremely close to the massive southern California market. Some farm managers believe they will be able to deliver high quality fresh (and even live) shrimp which would command premium prices.

XIII. RESEARCH

Mexico has one of the most comprehensive aquaculture research programs in Latin America.[229]

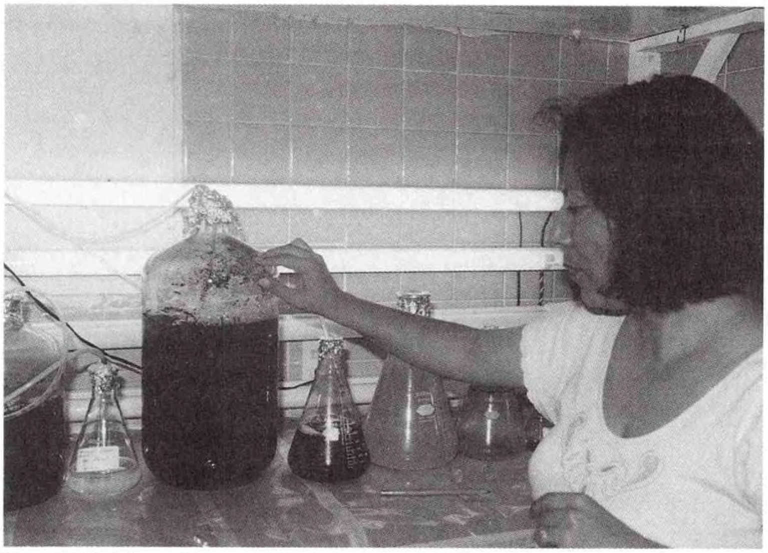


Photo 12.--Mexico. Algae research being conducted at the Puerto Morelos CRIP.

Much of the research conducted during the 1970s and 1980s focused on the culture of species other than shrimp. This reflected the Mexican Government's emphasis on expanding the production of low-cost food for the domestic market. Nonetheless, considerable work has been done throughout Mexico on both marine and freshwater shrimp culture, especially since the mid-1980s.

A. Marine

A number of Mexican research groups have worked on marine shrimp culture. Several university groups have been active, including the **Universidad Autónoma de Baja California, Universidad Autónoma de Guadalajara, Universidad Autónoma de Nuevo Leon, Universidad Autónoma de Sinaloa, Universidad Autónoma de Tamaulipas, Universidad Autónoma Metropolitana**, and **Universidad de Sonora CICTUS**. The **Universidad Nacional Autónoma de México** has also sponsored research, at both its Mexico City central campus and at regional centers in Sinaloa and Quintana Roo. Three **Centros de Estudios Tecnológicos del Mar** (CET-Mar) located in Mazatlán and Teacapán (Sinaloa) and La Paz (Baja California Sur) have worked on marine shrimp grow-out. The La Paz facility has also investigated pl production. The **Centro de Investigación Biologica** (CIB) in La Paz hopes to finish a new hatchery in 1992 to expand its research program. SEPESCA's Instituto Nacional de Pesca maintains 12 **Centros Regionales de Investigaciones Pesqueras** (CRIPs), of which the centers at Campeche, Manzanillo, Mazatlán, Puerto Morelos, and Tampico have conducted some marine shrimp culture studies and published several reports .

The authors have little information to evaluate the quality or impact of Mexican research. Mexican researchers during the 1980s carried out much of their shrimp culture work largely in isolation from foreign groups. Only limited work has been conducted in cooperation with foreign research groups.[230] The principal countries reporting the major findings in this very technical field have been Japan, Taiwan, the United States, and to a lesser extent France. Compared to most other Latin America countries, Mexico has permitted very little foreign involvement in its shrimp culture industry. (See Section IX. Foreign Participation.) This isolation, intended to maintain national control over a potentially lucrative resource, had the unintended impact of isolating Mexico from foreign technical advances. As the Mexican Government excluded private commercial development, foreign research groups could gain little benefit from Mexican projects. Thus, Mexican growers were largely isolated from the foreign research which elsewhere in the 1980s helped produce

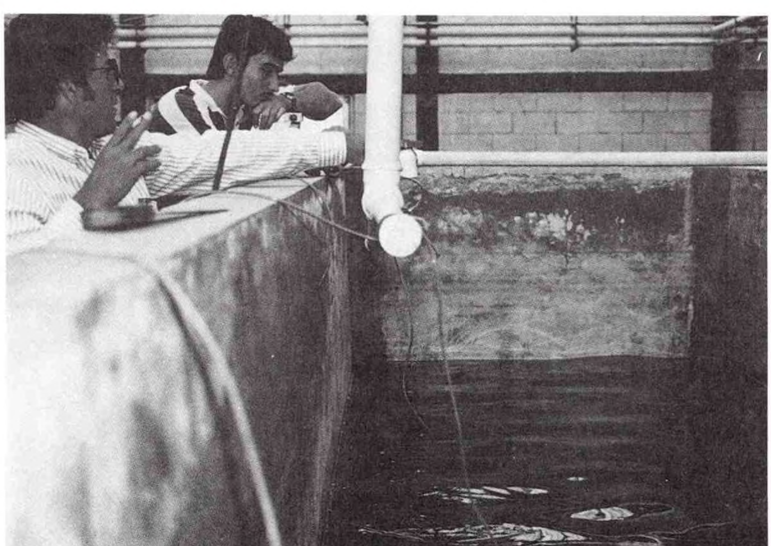


Photo 13.--Mexico. Considerable work is underway at both marine and freshwater hatcheries. Dennis Weidner

a revolution in commercial shrimp culture. This isolation is beginning to change as the Government opened the industry to private investment since 1986. (See VII. Legal and Social Framework.) SEPESCA has also sponsored a variety of symposiums and training programs which include substantial international participation.[231]

Some observers are concerned with what they see as the failure of Mexican researchers to conduct studies that yield results of practical use to farm managers. Growers complain that much of the research conducted has been theoretical with little thought concerning how to apply the results to actual commercial operations. University and other groups have been studying shrimp culture for more than 20 years. One local observer reports, however, that research groups have given little attention to commercial considerations, such as practical innovations to lower production costs.[232]

Some observers are pessimistic about Mexico's ability to initiate an effective shrimp culture extension system to assist growers. This is a concern expressed throughout the region. No Latin American country has so far been able to do so. Even a country like Ecuador, with shrimp exports approaching $0.5 billion annually, has been unable to initiate a successful extension program.[233] The principal problem is that experts with technical training and experience are in high demand by the major groups entering the industry. As a result, they can command much higher salaries than the government can offer.

B. Freshwater

Mexico has also conducted some research on freshwater shrimp, although the authors have only limited information on that work. A recent report listing aquaculture research mentions only a few Mexican studies of freshwater species.[234] Very little attention has been given to indigenous species. Much of the Mexican research in Mexico has been conducted on an imported species, *M. rosenbergii*.[235]

A variety of institutions have sponsored research on freshwater shrimp. The **Instituto Politécnico Nacional**, **Instituto Tecnológico de Monterrey**, **Universidad Autónoma del Estado de Morelos**, **Universidad Autónoma de Guadalajara**, **Universidad Autónoma de Sinaloa**, **Universidad Nacional Autónoma de México**, **Universidad de Sonora**, and **Universidad Veracruzana**, and the CIB have all sponsored research at their respective facilities. The Government has also supported and published research through the **Centro de Estudios del Mar**, various **CRIPs**, and the **Instituto Nacional de Investigaciones de los Recursos Bióticos**.

XIV. POSTLARVAL SUPPLY

The availability of seedstock is one of the most critical problem faced by Mexico's shrimp growers. Mexican growers clearly have made substantial progress in increasing production of pl seedstock, reflected in steadily improving harvests. Despite the availability of wild stocks, however, many growers report difficulty obtaining adequate postlarvae. The Government has launched efforts to expand both wild collection and hatchery production. Substantial increases have been reported in wild pl collection, but hatchery production, while increasing, is still limited. The Government, however, continues to restrict pl imports.

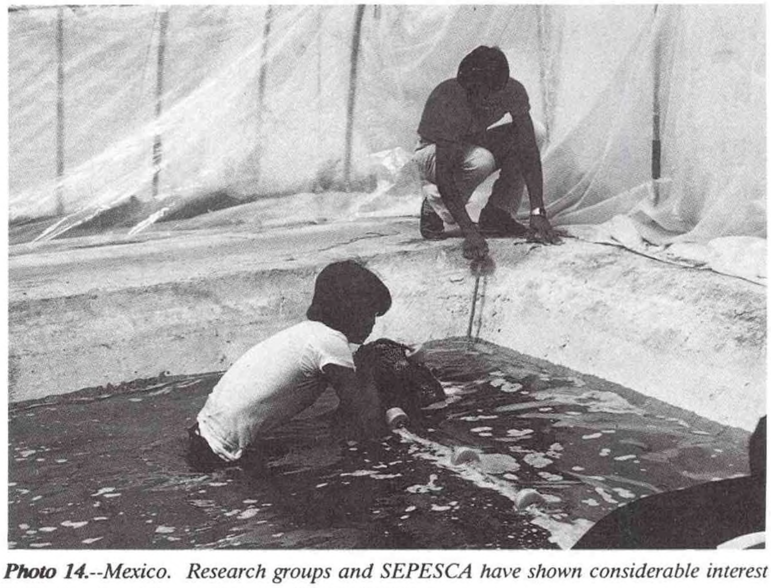


Photo 14.--*Mexico. Research groups and SEPESCA have shown considerable interest in freshwater shrimp culture. Dennis Weidner*

The availability of **wild seedstock** suitable for pond culture is one advantage Mexico has over growers in several other countries.[236] While the quantities available are not precisely known, most observers believe that substantial quantities can be collected. Despite the availability of wild pl, many growers have reported difficulty in regularly stocking their ponds. Current collection efforts are increasing, but still do not appear to be effectively utilizing the potential resources. This is surprising at such an early stage of the industry's development because Mexico has built only a fraction of the ponds that Government officials believe are possible, and as a result pl demand is still relatively limited. Government plans for cooperatives to efficiently develop a new pl collection industry have proven overly optimistic. Pl production has been further hampered by Government delays in issuing required collection permits.[237] While the cooperatives may eventually organize an efficient operation, their progress to date is not encouraging.

Mexico is also conducting a major **hatchery development** program. Mexican groups have built more than 20 hatcheries and several more are in the planning stage. Technical assistance has been obtained from foreign consultants. Hatchery operators have to date, however, made only limited progress in supplementing wild pl production. Significant technical problems have been reported at many of the new hatcheries. Shrimp hatcheries require relatively sophisticated technology and the *P. vannamei* pl that growers prefer is an especially difficult species with which to work. Thus, Mexican hatchery operators, many with only limited experience, are reporting the same start-up difficulties that have been experienced in Ecuador and other countries.

The resulting pl problem may become increasingly severe as Mexican growers expand pond area and thus pl demand. The apparent pl shortage, however, has so far not prevented impressive harvest increases, though growers say that more ponds could have been stocked and higher stocking densities employed had they been able to obtain adequate postlarvae. This is probably one factor explaining the low Mexican pond utilization rates (appendix D2).[238] Some growers are concerned that unless the seedstock problem is resolved, the industry's current rate of expansion may slow. Some of the smaller and less well-financed growers may be forced to curtail or even close operations.

A. Wild Collection

Mexican growers currently collect wild pl to stock their ponds. Many early entrants in the industry were convinced that collecting wild pl was the easiest, least expensive way to stock ponds, following the successful Ecuadorean example.[239] Given the presence of wild *P. vannamei* stocks, Mexican growers assumed that adequate pl could be easily collected in their extensive Pacific coast estuarine systems. In addition, growers generally desired wild seedstock because of its superior survival and growth characteristics.[240] Mexican growers had no realistic option, however, but to rely on wild collection because the country's few hatchery projects were producing negligible quantities of postlarvae. Another option, the import of pl, has been restricted by SEPESCA out of concern over the possible introduction of diseases and parasites.[241]

The availability of pl in Mexican estuaries has not been quantified with any precision. SEPESCA has sponsored only limited research to assess pl availability.[242] SEPESCA estimates that about 1.5 billion pl could be collected annually without depleting the resource and impairing the capture fishery,[243] though the authors are unaware of the criteria used to calculate this estimate. While the SEPESCA estimate cannot be confirmed at this time, most observers are convinced that fairly large quantities can be collected.[244] Given the size of the wild shrimp stocks, this would appear to be a relatively low estimate. Actual data on pl availability is very limited. While some data have been compiled on specific estuaries for short periods, the authors know of no comprehensive annual survey. One factor which needs to be addressed is the seasonal fluctuation of pl availability. The authors know of no detailed study on seasonal availability. One SEPESCA report on the potential for shrimp culture along the Pacific coast indicated that pl availability was spread over a longer period of time in the south than in the north.[245] Local observers report that pl is most available during the summer and fall, although different observers provide slightly different accounts. One preliminary report indicates that pl is most abundant for 5 months each year from June to October.[246] Another observer indicates that wild pl is plentiful from June to November.[247] As in Ecuador, the availability of wild pl is also subject to sharp annual fluctuations as a result of changing climatic conditions.[248]

Growers appear to be expanding collections substantially, but little specific data is available to the authors on the actual quantity. SEPESCA estimated 1988 pl production at about 0.4 billion (appendix I3). Despite the rapidly increasing pl collections, growers appear to be barely keeping pace with the expanding pond area. Rough estimates of pl usage suggest that nearly 0.8 billion pl were collected in 1990. Unconfirmed reports suggest, however, that wild pl was extremely scarce in late 1990,[249] possibly reflecting an especially dry year. Even so, some indicators suggest that growers still collected as much as much as 1.5 billion pl in 1991. This is about what SEPESCA reported as the maximum quantity which could be collected. The largest quantities are collected in Sinaloa estuaries (appendix I3).[250] Little pl is currently being collected along the Gulf of Mexico, because the Gulf species have not proven suitable for pond culture. (See Section III. Species.)

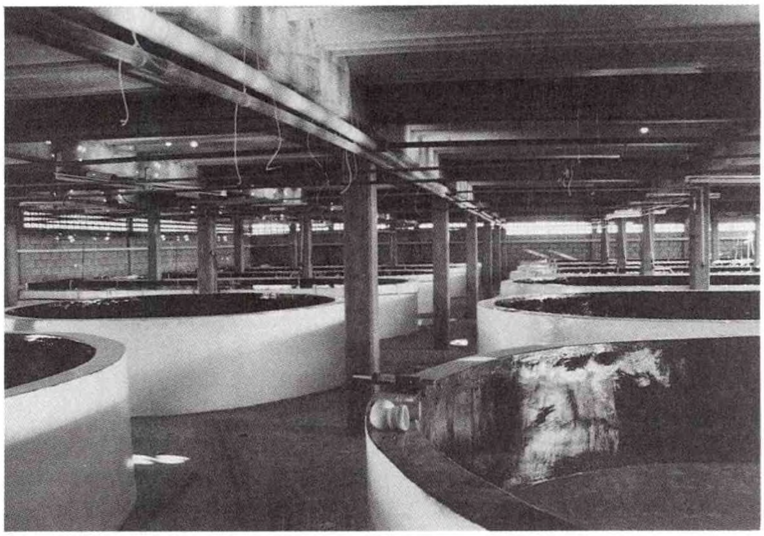


***Photo 15.**--Mexico. Maturation facility at El Camaron Dorado near Huatabampo, Sonora. © Leland Lai, Aquafauna, Bio-Marine*

SEPESCA restricts the right to collect and sell pl and gravid females exclusively to cooperatives.[251] SEPESCA officials apparently concluded that while the cooperatives have had difficulty conducting growout operations, they would be able to conduct an essentially artisanal fishery to collect pl as practiced in Ecuador.[252] Cooperative efforts in Mexico, however, have so far proven less than satisfactory and growers complain of pl shortages and difficulty dealing with the cooperatives. SEPESCA reportedly maintains that the shortages are only temporary and will be resolved as the cooperatives gain experience and improve collection techniques. Unconfirmed reports suggest that this is not happening. SEPESCA officials have not issued needed collection permits in a timely fashion.[253] The cooperatives do not appear to be developing an effective artisanal collection industry. Instead, many are simply charging fees to growers who then must collect the pl themselves. Growers seeking to obtain pl have no open market where they can purchase seedstock from the cooperatives in a timely manner. Growers must follow a complicated, time-consuming procedure. They must negotiate a contract with a cooperative, obtain SEPESCA approval, and then separately conduct or arrange for the actual collection at their own expense.[254] The shrimp farmer thus is distracted from what should be the main concern--shrimp growout. Not only does the current system add unnecessary costs to obtaining pl, but the growers cannot be certain if pl can be obtained when needed.

Growers complain that their problems working with the cooperatives are compounded by difficulty dealing with SEPESCA. The most serious problem has been delays experienced in obtaining the needed collection permits from SEPESCA. These delays can be devastating. Because pl does not become available until June or July, even short delays may be enough to prevent growers from fully utilizing their ponds. Some growers report idle ponds in June and July 1991 were due to SEPESCA's refusal to issue pl collection permits. This limited their operations to only one crop -- which has proven extremely costly, especially for the more northerly located farms.

B. Hatcheries

Observers see the development of modern shrimp hatcheries as critical for the expansion of Mexico's shrimp culture industry.[255] Maturation hatcheries can produce year-round and thus supply growers during those months (December to May) when wild pl is scarce or unavailable. Reliable hatchery production could also provide pl for growers even when annual climatic conditions reduce the availability of pl in local estuaries. Hatchery pl will eventually be needed to stock the very significant area of future ponds projected for development. Some observers are concerned that pl demand is already reaching levels that cannot be supported solely by wild collections. In addition, hatcheries may be needed to supply *P. vannamei* pl for farms along the Gulf and Caribbean coast if the Government eventually approves its use.

Mexico is building a major shrimp hatchery industry. One observer reported in 1990 that Mexico had eight operational hatcheries,[256] but more current information suggests that several new hatchery projects are currently underway. The authors have received reports of about 20 facilities which were attempting to produce marine and/or freshwater shrimp pl during 1991, while as many as five additional marine hatcheries are planned (appendix

I1).

As could be expected from efforts to rapidly create a highly technical new industry, hatchery operators are encountering considerable difficulty.[257] Many of the new hatcheries have experienced significant start-up problems, but some progress is being reported. Two hatcheries are known to be currently producing pl on a regular basis, and a third is reported to be ready to begin production. Mexican hatchery pl production totaled about 0.1 billion in 1990. Unconfirmed reports suggest considerable progress at several hatcheries and pl production may have reached nearly 0.6 billion in 1991. Existing hatcheries could theoretically produce nearly 1.5 billion pl annually if they operated near capacity (appendix I1). Some observers are optimistic that the experience being gained will permit substantial production increases in 1992.

Most Mexican hatcheries have only recently been opened and as a result, few are reporting successful results. Little detailed information is available to the authors regarding individual hatchery operations. Most of the hatchery efforts to date in Mexico employ basic technology, relying on wild-caught gravid females to produce nauplii. Even so, many report significant difficulties and actual pl production is still very limited. Despite the limited results, for the first time a substantial number of projects are underway and increasing numbers of technicians are gaining experience, laying the groundwork for an important new industry. Most industry observers stress the need to improve hatchery operations[258] and insist that the success of current hatchery projects will have a major impact on the shrimp culture industry's development.

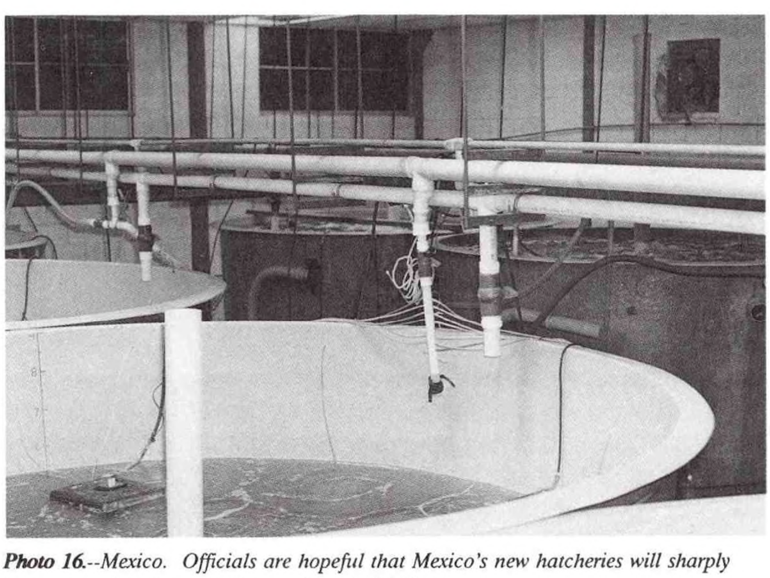


Photo 16.*--Mexico. Officials are hopeful that Mexico's new hatcheries will sharply increase seedstock production. Dennis Weidner*

Information on current hatchery facilities and their production status follows:

Acuícola Cultivos del Mar de Cortez: Located at Tastiota, Sonora, this hatchery produced about 3 million *P. vannamei* pl monthly in 1991.[259]

Acuacultivos del Pacífico: This hatchery was opened by a cooperative group in 1987.[260] Flood damage in 1990 reportedly forced the operators to close the facility.[261]

Acuacultores de la Peninsula: This hatchery is operated by a cooperative near La Paz, Baja California Sur. It has a reported capacity of 10 million pl monthly.[262] The primary species produced is *P. vannamei*.[263] In addition to producing pl, the hatchery has reportedly begun maturation of captive breeders, producing some 30 million nauplii monthly both for its own use and for sale to other hatcheries. The hatchery sold 50 million pl during 1991 to five farms in Sinaloa and one in Sonora, and expects to market both there and in the state of Nayarit.[264]

Aquagranjas: This hatchery reportedly has considerable experience producing freshwater pl, and recently added a maturation facility for marine shrimp. Located in Colima state, the operation sells to freshwater farms in Colima, Guerrero, Michoacan and Oaxaca, reportedly providing about 80 percent of the region's needs. The company is also developing a marine shrimp farm.[265]

Barra de Navidad: The Universidad Autonoma de Guadalajara (UAG) operates this small research hatchery in Jalisco state. The hatchery has been focusing on nutrition research, but plans to begin producing 1 million pl monthly in late 1991. The facilities consist of four maturation tanks of about 3 kiloleters (kl) each, six 1.5 kl larviculture tanks, seven 1 kl tanks for growing microalgae, and six *Artemia* tanks. There are currently no operational farms in the vacinity, though the UAG would like to open an experimental growout farm further south, close to Tecomán, Colima.[266]

BIOTAC, S.A.: The company operates one of the most successful hatcheries in Mexico. The hatchery is located in Escuinapa, Sinaloa, and was producing 30 million pl monthly as of mid-1991. This is a significant improvement over

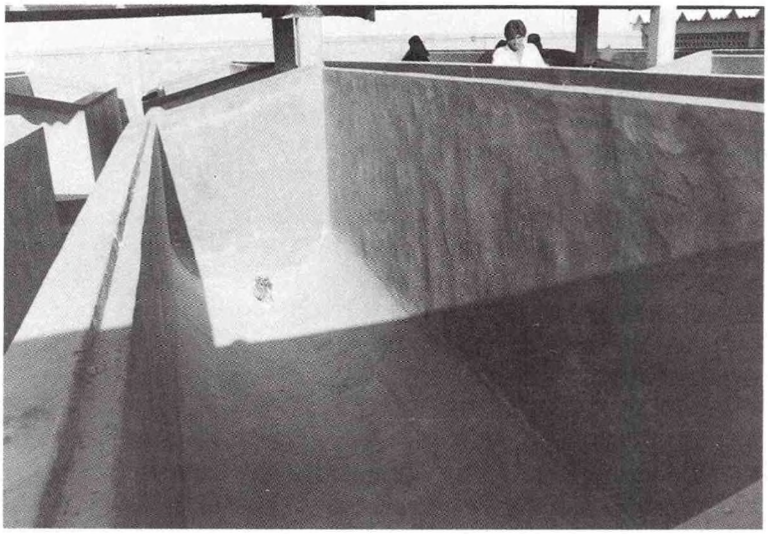


Photo 17.--Mexico. Polyurethane insulated, larval rearing tanks at El Camaron Dorado in Sonora. © *Leland Lai, Aquafauna, Bio-Marine*

the 6-7 million pl monthly average reported during 1990. The primary species produced is *P. vannamei*, though the hatchery is also reportedly producing smaller quantities of *P. stylirostris*. BIOTAC produces pl both to stock its own farm and for sale to other growers.

Biotecmar: A cooperative in 1986 opened a small hatchery with assistance from CICTUS. Unconfirmed reports suggest that very limited runs were conducted in 1987,[267] but more current data are not available.

Camaricultores de Sinaloa: This private hatchery is another of the more successful Mexican hatcheries. It reportedly produced as much as 30 million *P. vannamei* pl monthly in 1991, selling to the many nearby farms. The sale price is reportedly $8 per 1,000 postlarvae. Hatchery representatives indicate few difficulties selling pl due to the shortage of wild-caught postlarvae.[268]

Centro de Estudios Tecnologicos del Mar (CET): This research hatchery, built with funding and technical assistance from Japan, consists of four larviculture tanks, a 1-kl microalgae tank, and a research lab. It produced between 1.5 million-2.0 million pl monthly in 1991. CET's primary objective is to train students and fishery cooperatives members to produce and handle shrimp postlarvae. CET also plans to experiment with shrimp growout in the near future.[269]

Centro de Investigación de Poslarva de Camarón (CIPC): The Universidad Autónoma de Tamaulipas (UAT) built a marine shrimp hatchery at La Pesca, Tamaulipas in 1987. This is the only significant hatchery project known to exist along the Gulf of Mexico coast. The hatchery reportedly achieved its first successful *P. vannamei* maturation run in early 1989,[270] and has a 50 million pl monthly capacity. Other observers are skeptical of such claims and the authors have no data substantiating significant pl production.

Centro de Investigaciones Cientificos y Tecnológicos de la Universidad de Sonora (CICTUS): The University of Sonora in cooperation with the University of Arizona and the Coca Cola Company opened an intensive shrimp farm and hatchery at Puerto Peñasco in 1973. The group worked primarily on *P. stylirostris*.[271] The U.S. participants withdrew in June 1980 as the result of a dispute over the utilization of the postlarvae.[272] Details on current work at the facility are unavailable.

El Tambor: This hatchery is currently being constructed at a reported cost of $2.5 million in Culiacán, Sinaloa. The facility is owned by the Federación de Cooperativas del Centro de Sinaloa, an association of local cooperatives. The hatchery will provide pl to both cooperative and private shrimp

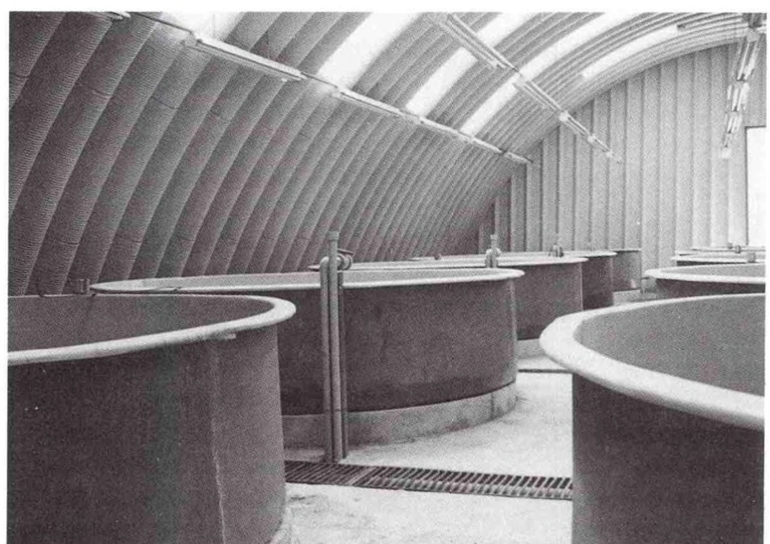


Photo 18.--Mexico. Larval rearing tanks at the La Pesca hatchery in Tamaulipas along the Gulf of Mexico coast. *Dennis Weidner*

farms in the area, though the nearest growout ponds are reportedly 50 km away. The hatchery has not yet produced any pl, and the authors have no information on its capacity or species to be produced. Technical assistance is reportedly being provided by a Panamanian company. Construction delays and financial problems[273] indicate that the hatchery will not open until mid-1992 at the earliest.[274]

Instituto Nacional de Pesca (INP) labs: SEPESCA's INP reportedly operates a number of research hatcheries at its various Centro Regional de Investigación Pesquera (CRIPs). The **Puerto Morelos** CRIP (Quintana Roo) is reportedly trying to develop methods to produce Atlantic-coast species, primarily *P. brasiliensis*.[275] The lab has a water filter, four 1.5 kl, four 0.5 kl tanks for raising postlarvae, and eleven 0.2 kl basins to spawn broodstock. The facility was damaged by Hurrican Gilber. Two trials with limited results have been conducted and the researchers hope to begin production by the end of 1992.[276] The **Puerto Pesca** (Tamaulipas) CRIP is also reportedly working with Atlantic-coast species, and achieved trial monthly runs of nearly 20,000 postlarvae. The Puerto Pesca lab may operate as a part of the CIPC hatchery mentioned above, though the authors have been unable to obtain information to confirm this. SEPESCA also operates a CRIP in **Tampico** (Veracruz) and **Lerma** (Campeche).[277] Other INP labs produce freshwater shrimp postlarvae.[278] No additional information is available to the authors on these facilities.

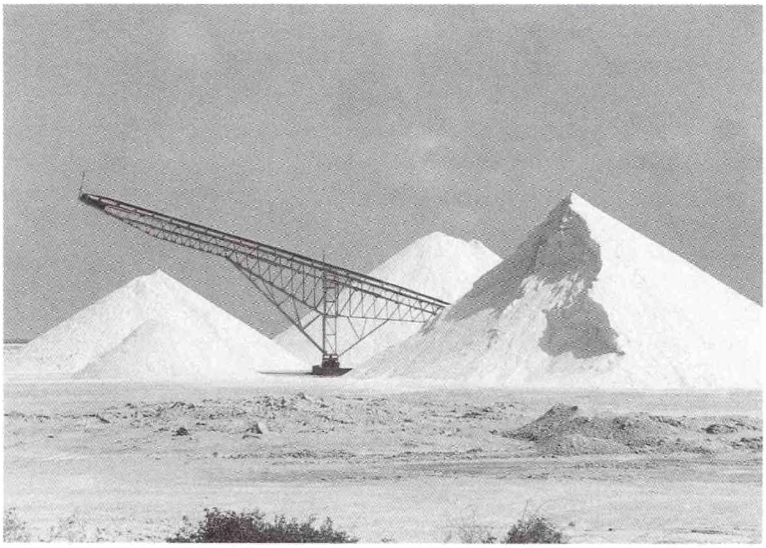


Photo 19.--Mexico. Salt companies, such as Industria Salinera de Yucatán, are studying possible Artemia production. *D. Weidner*

Other university facilities: Press reports indicated that other Mexican universities are participating in hatchery work. The University of Sonora (USO) reportedly operates a second facility, besides the CICTUS Puerto Peñasco lab described above, at Guaymas. USO is believed to be working with marine species, though the authors have no additional information. The University of Acapulco is reportedly working with freshwater species, but the authors cannot confirm this.

New hatchery projects: The authors have received reports of an additional 5 hatchery projects which are currently being considered. All together, these projects if constructed could produce some 100 million pl monthly.

Some observers question the economics of Mexican hatcheries. They question whether hatcheries can operate profitably. Most growers will purchase wild pl when it is available. Not only is wild pl cheaper, but it appears to be stronger and exhibit superior pond growth and survival characteristics. There are only about 6 months when wild pl is unavailable.[279] This thus limits revenue and restricts profitable operations to only half the year. Ecuadorean hatcheries, for example, continue to experience serious financial problems because growers turn to wild pl when it is available.

Mexican hatchery research efforts have focused on *P. vannamei* and *P. stylirostris*. Some work, however, has also been conducted on other species.[280] Relatively little information is available to the authors on the work conducted. The larviculture work has been conducted by several research institutions. (See Section XIII. Research.)

Mexican officials are hopeful that the *Artemia* needed for hatchery operations can be produced domestically. Considerable research on *Artemia* has been conducted by CETMAR, ICML/UNAM, INP, UAM, UNAM, and other Mexican research groups.[281] Mexican research groups are assessing domestic *Artemia* strains[282] as well as experimenting with introduced strains.[283] Studies have been conducted in

Jalisco, México, Quintana Roo, Sinaloa, Sonora, Yucatán, and other states. CETMAR has since 1986 organized seminars and conducted courses on both shrimp and *Artemia* culture. Currently much of the *Artemia* used by the hatcheries is being imported. Several locations in Mexico, however, are believed suitable for *Artemia* culture. One group reports that sites in Sonora appear especially favorable.[284] Various groups have already begun *Artemia* production in Sinaloa, Yucatán, and other states. The first company to attempt the commercial production of *Artemia* is believed to be Acuelimentos Artemia which is working at Ceuta Bay between Mazatlán and Culiacán in Sinaloa.[285] Another group is known to be working in Yucatán.[286]

C. Supply and Demand Situation

Precise data on Mexico's pl supply are unavailable. Rough approximations clearly suggest, however, that Mexico is making sustained progress in increasing pl production. Production probably totaled about 0.4 billion pl in 1988, mostly wild-collected postlarvae (appendix I3). Production may have increased to nearly 2.1 billion pl in 1991, when growers probably collected 1.5 billion wild pl and hatcheries produced about 0.6 billion postlarvae (appendix I2).[287] Unlike growers in other countries, Mexican growers have not supplemented domestic pl supply by importing postlarvae. Government regulations make it extremely difficult to import postlarvae.[288]

Demand for pl is also difficult to assess, though it clearly is expanding along with pond area (appendix I4).[289] Estimates of pl demand vary widely. One estimate, based on an assessment of SEPESCA data on operational pond area and culture methods, suggests demand for pl may have exceeded 0.7 billion in 1990. Other estimates give somewhat higher quantities. SEPESCA estimated pl demand at over 0.4 billion, when harvests were only 2,400 t in 1988. This would suggest that growers needed nearly 0.9 billion pl in 1990 to harvest 5,300 tons.[290]

Current Mexican pl production, wild collection supplemented with hatchery production, appears inadequate. Growers have made substantial progress in increasing production. Even with the current, relatively modest pond area, however, growers have reported difficulty obtaining sufficient postlarvae. Despite the impressive harvest increases, efforts to increase wild collection and hatchery production do not appear to have kept pace with pond construction. The resulting pl shortage has been one cause of the large number of unstocked ponds,[291] though other factors such as poor pond design and management are partly responsible. The pl shortage has also impaired optimal pond management, forcing growers to use undesirably low stocking densities, which results in low yields. The ability of Mexican growers to expand pond area and harvests further in 1992 will largely depend on their success in increasing pl production.[292]

Realistically, there are only two immediate options to expand pl availability. Some observers, however, are concerned about the potential impact of both these options.

Improve wild collection: Relatively simple, inexpensive measures could result in very significant increases in collection efforts. One such measure would be to insure the timely issuance of collection permits. Another would be to open the collection to independent groups not associated with cooperatives. No one knows, however, realistically how much more pl can be collected without adversely affecting stocks.

Permit imports: Regulations could be modified to ease pl import procedures. *P. vannamei* is readily available from the expanding hatchery industries in Ecuador and Panama.[293] Some observers believe, however, that this is not a desirable option. SEPESCA appears unlikely to take this step out of concern over the importation of parasites and pathogens associated with exotics.

Hatchery production is the long-term solution to the pl supply problem. It is, however, a highly sophisticated undertaking which will require major investments and some time to perfect. Based on the experience of other Latin American countries, Mexico's new hatchery projects will probably continue to experience a variety of technical problems and will be unlikely to fully meet industry needs for several years.

Little data is available on current Mexican pl prices. However, one observer has estimated that supplying pl for an extensive farm would run about $75 per ha, compared to $500 per ha for a semi-intensive farm.[294]

Wild pl: Wild pl prices are not readily available. One industry source placed the price in early 1992 at about $3.25 per 1,000 pl.[295] Some growers complain, however, that cooperatives have not been selling pl, but instead simply charging fee to allow growers to collect the pl themselves. One observer reported that in 1991, the fee for wild pl, legally available only from cooperatives, was set at $3 per 1,000 postlarvae.[296]

The cost to the growers, however, is the fee plus the actual cost of collection. Data on collection costs are not available.

Hatchery pl: The authors have been able to obtain only scattered information on hatchery prices, in part because so few hatcheries are producing postlarvae. There seem to be wide variations between individual hatcheries. The University of Sonora hatchery sold *P. stylirostris* pl to local farmers in 1987 at a price of $25 per 1,000, while more recent information is not available.[297] The University of Tamaulipas hatchery at La Pesca sold *P. vannamei* pl for $7.00 per 1,000 in 1989, but this probably represented a substantial subsidy.[298] One observer reported marine pl in early 1992 cost about $8 per 1,000.[299] The Aquagranjas hatchery reported selling freshwater pl for about $16.40 per 1,000 in 1991.[300]

Some growers are attempting to organize associations to build their own hatcheries. These associations would informally bring together several farms to operate a hatchery and purchase seedstock. They believe operating their own hatchery would reduce pl costs and insure an adequate supply during the off-season when wild pl is unavailable.[301] Each farm in the association would be able to purchase pl at cost, and the hatchery would thus be assured a steady market. One observer estimates that such arrangements could lower the price of hatchery pl to $6 per 1,000.[302]

XV. FEED

Several companies have begun producing shrimp feed in Mexico. The authors have no data, however, on the quantity or quality of domestic feed production. Several companies produce aquatic feeds for Mexico's growing aquaculture industry, but only a few of these offer a freshwater or marine shrimp ration.[303] Some observers maintain that current production is insufficient and of poor quality,[304] but insufficient data is available to verify such conclusions. In addition to domestic production, a small quantity of feed is also imported.[305] Both domestic products and imports, however, do not fully meet the rapidly growing demand. To assure a reliable supply of feed, some of the more technologically advanced farms have reportedly built their own small feed plants.[306]

The industry's ability to rapidly expand feed production or to produce quality feed is unclear. Mexico is a major producer of animal feeds to support the country's massive poultry and livestock industry. Several producers are large corporations which have substantial technical capabilities and financial resources. Even these companies will face, however, major problems. Mexican companies have only recently begun to produce shrimp feed.[307] Few feed companies have initiated the research programs needed to produce effective feed formulas. The authors know of no major research effort initiated by any Mexican feed company, though some academic and trade groups have been researching shrimp nutrition. Some companies are establishing commercial relationships with foreign firms that have technical expertise in shrimp nutrition.[308]

The economics of producing shrimp feed in Mexico are also unclear. Several other countries with important shrimp culture industries (Ecuador, Panama, and Peru) also produce substantial quantities of fishmeal, a major ingredient. Shrimp feeds contain substantial quantities of fishmeal because shrimp require higher protein content than poultry and livestock.[309] Feed is a major operating expense at semi-intensive farms, and protein content is an important price factor.[310] This has prompted some researchers to seek cheaper, alternative protein ingredients.[311] Mexico produces fishmeal, but already needs to supplement domestic production with imports to supply the current massive demand of the country's animal feed industry (appendices H1-2). Any substantial increase of shrimp feed production will require expanded imports of fishmeal and other ingredients.

Mexico could eventually produce some feed by utilizing shrimp heads and other waste products at fish and shrimp processing plants. Almost all of the country's commercial shrimp catch is deheaded at sea and landed as tails. The economics of shrimp fishing suggest that this is unlikely to change in the foreseeable future. (See XVI. Processing.) Cultured shrimp harvests, however, are deheaded at the processing plants and the head could readily be used to produce meal. At least one group has investigated the feed value of shrimp byproduct meals.[312] As quantities of cultured harvests increase, utilizing shrimp heads could become a substantial potential resource for feed production. The authors are unaware, however, of any processing plants which have yet installed a meal plant to utilize such waste products.

Demand for feed in Mexico is increasing. The Mexican shrimp culture industry has expanded sharply since 1986. Both the expansion of pond area and shift to semi-intensive methods are escalating feed demand. If Government projections of expanding pond construction prove even partially correct, the demand for shrimp feed will increase very substantially during the 1990s.

The authors have been able to obtain only limited information on companies currently marketing shrimp feed.

Abastecedora de Forrajes, S.A.: The Guadalajara-firm produces shrimp and other animal feeds.

Albamex: The company's Guadalajara plant produces shrimp and catfish feed. No additional information is available.

Alimentos Acuícolas El Pedregal: This Mexican-owned company initially produced feeds for rainbow trout, from which it has diversified to produce a variety of feeds for other fish and shrimp. El Pedregal has reportedly just opened a new plant in the state of Mexico, just west of Mexico City.[313] Since 1989, the company has entered into a joint venture with the U.S. fish feed company, Silver Cup, with which it plans to produce feeds for both marine and freshwater shrimp. Feed formulations will reportedly include fish, soybean and wheat meals, fish oil, and livestock by-products.[314]

Coralesa: The Guadalajara-based company produces feed for both marine and freshwater shrimp, as well as for finfish. No additional information is available.

Forrajera El Barrio: This Mexican-owned company is based in Sinaloa. No additional information is available.

Forrajes Payan: This company produces marine shrimp feed in Culiacán, Sinaloa.

Nicolini: The Peruvian feed company, Nicolini Hermanos (NH), is now selling small quantities of its Nicovita shrimp feed. The company is reportedly well-regarded, even among its competitors, for producing good quality feed.

Nutripac: This company is reportedly based in Sinaloa and exclusively produces shrimp feed. The authors have no additional information on the company.

Purina: Purina is reportedly the dominant shrimp feed producer in Mexico, with a market share of more than 60 percent.[315] The company has just completed a major investment in its Mexican operation to improve shrimp feed quality, especially water stability.[316] Purina has access to the substantial research conducted in the United States and by Purina affiliates in other Latin American countries. Shrimp feed, however, currently makes up only a small portion of the company's production, which focuses primarily on poultry and other animal feeds. One Purina plant located in Tehuacán, Puebla, produces various aquatic feeds including freshwater shrimp feed as well as feeds for catfish, tilapia and trout. Another Purina plant in Sonora state produces marine shrimp feed.[317]

Ziegler: This U.S. feed company has exported some shrimp feed to Mexico in the past, though current sales are reportedly very limited. The company is currently seeking local partners for potential franchise agreements to build feedmills in Mexico in cooperation with **Iberson International**, a U.S. feedmill design and fabrication concern.[318]

XVI. PROCESSING

Mexico's expanding shrimp culture industry benefits from the country's established processing industry. Mexican companies have been packing shrimp for sale on the international market, particularly the United States, for many years and have generally acceptable quality standards. Standards for shrimp and other export products are higher than for products marketed domestically. (See Section XVII. Marketing.) As wild shrimp catches have declined substantially in recent years, there appears to be significant excess processing capacity. Packers should theoretically be able to handle any foreseeable increase in pond harvests during the next few years with only minimal capital investment. Some reports suggest, however, increasing obsolescence of the older plants along with an overall decline in the infrastructure of the capture shrimp fishery.[319] If these reports are accurate, this could present a problem and may impair the quality of Mexican products. Inefficient plants may make it difficult for Mexico to meet increasingly stringent sanitary requirements in the international marketplace. Mexican officials are concerned about maintaining quality standards and the INP is planning a mandatory inspection program which it hopes to implement during 1992.

A. Plants and Capacity

Mexico has traditionally operated the largest shrimp processing industry in Latin America.[320] SEPESCA reports that the industry processed more than 60,000 t of shrimp annually throughout the 1980s. The industry processed over 77,000 t of shrimp in 1987.[321] Production declined to 66,000 t in 1988. Much of Mexico's production is frozen. Substantial quantities of shrimp are also marketed fresh in Mexico. Much of this fresh product, however, is taken by poachers and marketed illegally. As a result, no official statistics are available to assess the quantities involved.

Mexico appears to have the capacity to process significantly larger amounts of shrimp, though many plants are reportedly obsolete or in poor repair.[322] One report indicated that Mexico had 411 seafood processing plants as of 1991, of which only 331 were actually in operation (appendix J2).[323] Almost all of these packing plants process some shrimp. Shrimp represented about one third of the seafood products processed and frozen at these plants between 1986 and 1988.[324]

The processing industry is dominated by privately owned companies. While shrimp fishing was reserved to the cooperatives under Mexican law, private investors were allowed to continue operating packing plants. Private companies packed nearly 70 percent of the shrimp handled in 1988. Cooperative plants packed 29 percent and state-owned plants only 1 percent.[325] The private role appears to be expanding. One article indicated in 1991 that the proportion of privately owned plants has increased to over 75 percent.[326]

B. Quality Standards

The authors know of no empirical study assessing the quality of Mexican shrimp exports. Mexico has been exporting shrimp to the United States for many years. Shrimp prices are in part a reflection of quality, and Mexican shrimp on the U.S. market are consistently priced above imports from other countries (appendix F4). Mexican white shrimp are still viewed as a premium product and command higher prices than white shrimp from major competitors (appendix F5).[327] Price differentials with other species such as Asian black tigers are even larger. Much of the U.S. shipments are made through state-owned Ocean Garden Products (OGP).[328] The company is the largest single U.S. supplier. OGP has considerable familiarity with the U.S. market and conducts a special program to help fishermen and processors meet U.S. quality standards.

Shrimp packers have generally exceeded the domestic quality standards.[329] The demands of the international market provided a strong incentive for packing plants to maintain high quality standards. In addition, OGP monitors the quality of the plants from which it purchases shrimp -- reportedly setting a standard slightly higher than required by U.S. authorities to minimize the possibility of a rejected shipment.[330] Japanese importers also reportedly monitor the plants from which they purchase shrimp.

Expanding Mexican cultured shrimp harvests may enable packers to improve quality standards. Growers are able to deliver their harvest to processing plants within hours of harvest. The resulting processed product is thus fresher and has a longer shelf life than the shrimp landed by fishermen, some of which may have been held up to 2-3 weeks at sea in trawler holds. Some growers are even assessing the possibilities of supplying live shrimp to the U.S. market. The proximity of growers in northern Mexico to the large market in southern California could prove to be a substantial advantage.

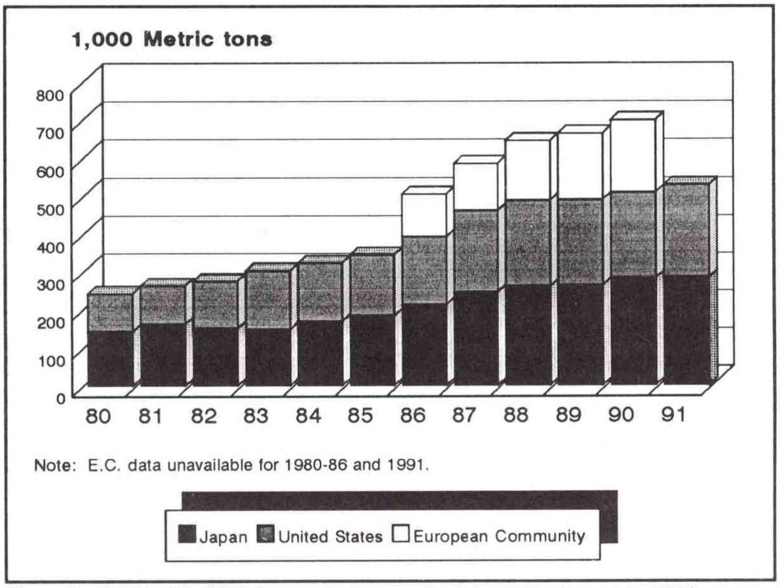


Figure 9.--World. World shrimp trade increased substantially during the 1980s.

Mexican officials are currently looking at ways to improve quality standards at seafood processing plants. SEPESCA is planning a mandatory seafood quality control program, in conjunction with the Secretaria de Salud and the Secretaria de Comercio y Fomento Industrial. SEPESCA's INP is currently developing product standards and the Government hopes to implement the new program in 1992.[331] The program would apply the principles of Hazard Analysis Critical Control Points (HACCP) to the monitoring of Mexico's packing plants. Several packers in the Matamoros area have independently decided to participate in a pilot program to assess HACCP principles.

XVII. MARKETING

Mexico primarily markets its shrimp in export markets, though it also has a strong domestic market. The primary export market has been the United States. Mexico dominated the U.S. market for imported shrimp during the 1960s and 1970s. During the 1980s, however, Mexico steadily lost market share in the United States as it failed to keep pace with the rapidly expanding production of Ecuador's and the Asian countries' developing shrimp culture industries. While the major world markets for shrimp greatly expanded imports during the 1980s, Mexico's exports slipped (figures 9 and 10). As a result of falling production levels, the industry has not yet followed the lead of several other important Latin American shrimp producers in developing a new European market.

A. Domestic Market

Mexico has a substantial domestic shrimp market. Mexican domestic prices for shrimp sometimes exceed the international market price (appendix F2).[332] Mexican consumers generally prefer fresh or frozen headless product.[333] This may reflect in part product availability because the trawler fishermen dehead the catch at sea. It may also reflect processing patterns at most packers.

Analysis of the domestic Mexican shrimp market is difficult because of the lack of reliable statistical data. Very substantial quantities of shrimp are marketed illegally and not recorded in official statistics.[334] Much of this contraband shrimp is taken illegally by poachers. Substantial quantities are also taken by the cooperative fishermen but not reported officially. Almost all of this illicit catch is marketed surreptitiously, most of it as fresh product. Estimates of the amount involved vary. Some observers believe that very large quantities are involved, perhaps as much as 25-50 percent of the quantity legally reported.[335] As a result, available data probably significantly understates Mexico's shrimp catch and the importance of the domestic market.[336]

B. Export Markets

Much of the Mexican shrimp catch of acceptable quality is exported, according to officially reported statistics. As mentioned above, however, official data does not account for the massive illegal catch. Even so, the quantities exported are still very substantial and Mexico is a leading world shrimp exporter. Several countries surpassed Mexico in the quantities shipped during the 1980s (appendix K7). Most of Mexico's exports are marketed in the United States, where the country lost significant market share during the 1980s. Mexico's exports to the United States peaked in 1987, and have since declined. Mexico also markets small quantities in Japan, but shipments to Europe are still negligible (figure 10).

Growers are likely to follow existing marketing patterns and also primarily target the U.S. market, although expanded future shipments to Europe are also possible. Japan appears, however, to offer only

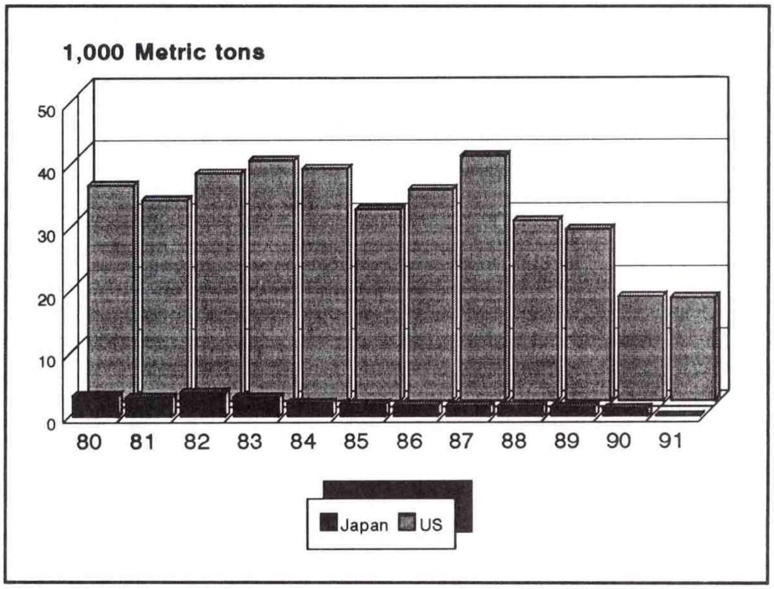


Figure 10.--Mexico. Mexico's shrimp exports have declined significantly in recent years.

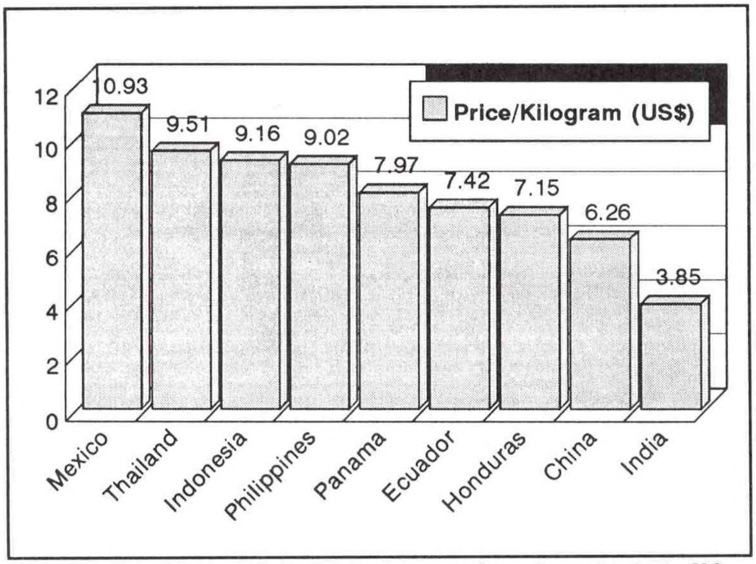


Figure 11.*--United States. Mexican shrimp command premium prices in the U.S. market, due in part to their large size and reputation for quality.*

minimal prospects for growers.

1. United States

The vast majority of Mexico's shrimp exports are marketed in the United States, the world's second largest shrimp importer (appendices K1-2). The United States consistently accounted for more than 90 percent of Mexico's total shrimp exports during the 1980s (appendices K1-2). Mexico's share of the U.S. market, however, has declined precipitously in recent years.[337] Mexico dominated the U.S. market during the 1960s and 1970s. Mexican exports to the United States totaled 34,500 t in 1980, or 35 percent of all U.S. shrimp imports. Mexican exports in 1990, however, declined to only 17,000 t, or less than 10 percent (appendix K9). The decline has resulted in sharply lower export earnings. Shipments to the United States in 1990 totaled only $177 million, less than half of the over $400 million earned as recently as 1987 (appendix K8). The deterioration of export earnings and market share has been caused by three major factors. First, several countries (China, Ecuador, Taiwan, Thailand, and others) aggressively expanded their shrimp culture industries during the 1980s, greatly increasing production and exports (appendices K7-8). Second, Mexico failed to develop its own shrimp culture industry, making it impossible to match the increasing shipments of major competitors. Third, Mexico's trawler catch declined sharply, especially in 1989 and 1990.

Mexican exporters nonetheless have a great advantage in the U.S. market as a substantial part of the Mexican catch is white shrimp. Whites are the species most highly regarded by U.S. consumers. In addition, large quantities of the trawler catch and exports are large shrimp, commanding premium prices (appendix K4). As a result, prices of Mexican shrimp consistently exceed those of competing countries (appendices F4-F5 and figure 11). Mexican farmers will benefit greatly from the U.S. consumer preference because they culture white shrimp. The growers, however, are unable to harvest the large sizes caught by fishermen. The established trading patterns, easy transportation links, and duty-free access also explain the country's reliance on the U.S. market. The state-owned company OGP has developed considerable expertise in the U.S. market. OGP reportedly sells more than 70 percent of the Mexican shrimp sold in the United States[338]

Virtually all of the Mexican exports to the United States are shipped as frozen tails. In past years, some breaded shrimp was also shipped, but quantities have declined recently. Exporters in recent years have increased shipments of peeled shrimp (appendix K4). Some growers are planning to develop a new trade for fresh and live shrimp. Growers in northern Mexico should be able to deliver harvested shrimp within 24 hours to the massive market in southern California. The high prices that such a high quality product commands could offset the less than ideal growing conditions and yields that the northern growers face.

One potential adjustment facing Mexico's shrimp industry could arise from efforts in the United States and Mexico to protect sea turtles. The U.S. Government has identified shrimp trawls as a major cause of turtle mortality, and implemented regulations for domestic fishermen designed to protect the turtles. The United States requires that shrimp harvesting countries wishing to sell shrimp in the U.S. market implement comparable measures.[339] Mexico has a major turtle protection program, primarily focused on protecting the turtles at nesting sites, and has given relatively little attention to protecting the turtles at sea. The U.S. law specifically requires efforts by commercial shrimp fishermen to reduce turtle mortality at sea through the use of turtle excluder devices (TEDs). Mexico announced in 1991 its intention to develop and implement an expanded sea turtle conservation program comparable to the

U.S. program within 3 years, which includes a major effort to introduce TEDs to the Mexican fleet. SEPESCA is currently conducting TED trials and plans to begin equipping trawlers in 1992. The U.S. law exempts cultured shrimp, but a system for differentiating wild and cultured shrimp has not yet been developed.

2. Japan

Mexico exports shrimp to Japan, one of the few Latin American countries to report such shipments (appendix K2). The quantities are relatively small, however, and peaked at a record 3,900 t in 1982. Shipments have since declined, and totaled only 1,300 t in 1990 and 100 t in 1991. The decline is notable as Japan measurably increased overall shrimp imports during the 1980s (appendix K1). Mexico has not shared in this expansion because of its inability to match the rapidly expanding production and lower prices of Asian shrimp farmers. Some observers also report a declining demand for the pink shrimp that Mexico was exporting. Mexican shrimp growers will probably have great difficulty competing with Asian farmers in the Japanese market. The Mexican growers are culturing white shrimp which commands premium prices on the U.S. market (appendix F4), but not in Japan. Japanese consumers do not share this preference for white shrimp, preferring several other species. Asian black tigers, for example, have achieved considerable acceptance in the Japanese market. In addition, the Japanese have access to the very large harvest of Chinese white shrimp at prices well below those of Mexican white shrimp (appendix F5).[340]

3. Europe

Mexico does not sell significant quantities in the European shrimp markets (appendix K2). Mexico's primary marketing efforts have focused on the United States, and the country has had particular difficulty meeting existing commitments in face of the continued low level of wild harvests during 1990 and 1991--hardly a position from which to initiate a major market expansion. Mexico also faces the more restrictive fishery import policies of the European Community (EC), and a bewildering array of laws, regulations, quality and packaging standards, languages and market preferences. Fishermen and packers have so far been unable to shift production to the whole product demanded in important European markets currently importing tropical shrimp. Growers may, however, be able to shift production more easily than trawler fishermen. The planned creation of a single European market in 1992 will likely resolve some of these complexities, but problems with languages and market preferences will remain for some time. Despite these problems, several Latin American countries are reporting considerable success in the European markets.[341] It is likely that any major expansion of the Mexican shrimp culture industry will result in at least some effort to penetrate the European market.

XVIII. OUTLOOK

Mexico appears to have considerable promise for developing an important shrimp culture industry, a potential which despite government promotional efforts is still unrealized. The Mexican Government initially restricted participation in the industry to the same cooperatives and *ejidos* which conducted the capture fishery. And though initial efforts were undertaken as early as the 1970s, they did not result in commercial-scale harvests. The early efforts suggested, however, that despite the lack of commercial success Mexico possessed a significant potential to culture shrimp. The country appears to have an appropriate climate (especially in the south), suitable species, large expanses of potential sites, energetic private investors, and a well-developed shrimp processing and exporting industry already in place. All of these factors suggest that Mexico will be able to develop one of the major shrimp culture industries in Latin America.

Recent government action which radically changed the industry's legal framework appears to be having a major positive impact. Growers are reporting impressive harvest increases following several years of virtual stagnation. The dramatic increase in Mexico's cultured shrimp harvest since 1985 appears to reflect the progressive liberalization of the laws restricting private investment in the industry. Beginning in 1987, growers have begun reporting steadily expanding harvests. The 1989 fisheries law revisions further liberalized restrictions on private investment, including authorization of foreign investment for the first time. These changes appear to be giving significant impetus to the industry's expansion. The increasing number of private investors helped expand the 1991 harvest to nearly 7,000 tons. The industry should achieve another major increase in 1992, perhaps as much as 10,000 t, if adequate pl can be obtained.

Some industry observers continue to express caution, despite the recent successes. It remains to be seen exactly how the revisions in the fisheries law will be applied and enforced. A number of structural and **institutional obstacles** may continue to inhibit the industry's growth. One such barrier is the *ejido* system. Much of the coastal land which appears most suited for aquaculture development is owned by *ejidos*, which have thus far been unable to attract private investment. The Government has approved major constitutional changes to the *ejido* system in 1992 which may result in the opening of *ejido* lands to private investment and ownership, but it is not yet clear precisely how the amendment will affect the shrimp culture industry. The cooperatives are another continuing problem. Though the cooperatives are no longer exclusively authorized to culture shrimp, they continue to operate a large number of farms. Their success or failure will still have an important impact on the industry as a whole. Little is known about the **environmental suitability** of large expanses of coastal areas. Observers are concerned about the temperate climate of northern Mexico. In other areas which may have highly suitable sites, such as Chiapas, the **infrastructure** is poorly developed. Many question the country's effort to increase production of **pl seedstock**, both through wild collection and hatchery production. Others question the suitability of Gulf-coast species for culture. Observers question how rapidly Mexico can **train personnel**, and design and **build farms**. Another important question for the Mexican industry and for potential investors is the future direction of **prices and costs**. The increases in cultured shrimp production by China, Indonesia, Thailand and other Asian countries has for years placed downward pressure on shrimp prices. The ability of Mexican growers to adjust to tighter margins and compete with the increasingly efficient operations in Asian and other Latin American countries is still unknown. Excessive **regulation** could still make the operation of private farms difficult, particularly where such regulations impede the ability of farmers to obtain pl seedstock.

As a result of remaining uncertainties, projections concerning future harvests vary substantially. Conservative estimates predict that Mexico should be able to harvest at least 25,000 t of shrimp by the year 2000.[342] Such a projection suggests slow and steady progress, with annual harvest increases averaging about 2,000 tons per year. Mid-range projections suggest harvests of about 35,000 t by 2000. This projection assumes that Mexico's shrimp farmers will be able to build farms at a rate comparable to Ecuador in the 1980s, though only by using available private lands.[343] An average rate of pond harvest increases of nearly 3,000 t would be necessary to achieve this level by 2000. A few observers are forecasting pond harvests exceeding 50,000 t by 2000.[344] This forecast seems rather optimistic, but is not impossible. It would depend on opening a substantial portion of Mexico's *ejido* lands to commercial development. Mexico's growers would need to achieve average harvest increases of nearly 6,000 t annually for this projection to be achieved by 2000. Many observers question Mexico's ability to design and construct ponds at such a rapid rate.

It is impossible at this time to determine which of the projections is the most likely to be achieved. A harvest of 25,000 t seems quite possible with current levels of new pond construction. It would mean primarily developing private lands, together with some success by existing cooperative and *ejido* groups. Given the substantial problems faced by the industry, this more conservative projection appears most plausible at this time. Mexico's capacity to expand its shrimp culture industry will continue to be limited by the availability of technicians and engineers needed to identify sites and design and construct farms. The country's credit shortage and problems associated with rapidly expanding seedstock and feed production may also restrict the industry's growth. The country's potential, however, is considerable and private investors have reported real success in only a short time. As a result, the possibility of a more rapid rate of development should not be dismissed.

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ENDNOTES

SECTION I. (Capture Fishery)

1. The cooperatives operate Mexico's fleet of commercial trawlers in coastal waters. Beginning in 1991 private investors were allowed to acquire shrimp trawlers and lease them to the cooperatives for the first time since 1982. The *ejido* fishermen employ small boats and various artisanal gear in the estuaries and other inshore waters.

2. Mexico refers to the Gulf of California as the Mar de Cortez.

3. While nearly 70 percent of Mexico's shrimp catch was landed in Pacific ports during 1989, the proportion has since declined because of poor Pacific-coast seasons. The Pacific catch fell to less than 61 percent in 1990, and was even lower in 1991. (See appendix E6.)

4. The Colorado River, which used to flow into the Gulf, now only provides an occasional trickle of highly polluted water.

5. A review of the situation in Sonora is available in Dennis Weidner, NMFS, "Mexico: Sonora Shrimp Situation, 1991," *International Fisheries Report*, in press; and Weidner, "Mexico: Sonora Shrimp Situation, 1990," *International Fisheries Report* (IFR-90/76), October 30, 1990.

6. Weidner, "Sinaloa Shrimp Update," *International Fisheries Report* (IFR-90/05), January 25, 1991; and Weidner, "Mexico: Sinaloa Shrimp Situation," *International Fisheries Report* (IFR-90/68), October 9, 1990.

7. One Mexican study estimated a shrimp maximum sustainable yield (MSY) for the Campeche Bank of about 26,000 metric tons annually.

8. The authors have attempted to express all wild capture and pond culture harvests data in whole weight. Some sources, however, do not specify tail or whole weight, so some quantities may be inadvertently expressed in tail weight. The trade data, however, is expressed in product weight because the authors do not have sufficient information to accurately convert to whole weight.

9. Some Pacific-coast cooperatives harvested only half the expected catch during 1990.

10. Dario Chávez H., L. Fueyo McDonald, M.A. Osuna Becerra, M. Pérez Navarro, and E. Sandoval, SEPESCA, "La temporada de pesca de camarón en 1988-89," *Acuavision*, Vol. 2, No. 19, 1990.

11. SEPESCA attributes the catch decline to overfishing and plans to intensify enforcement of fishery regulations such as closed seasons. Avelino Hernández Vélez, "Intensificará Sepesca la Vigilancia Para Evitar la Sobreeplotación de Especies: Jiménez Morales," *El Financiero*, November 15, 1991.

12. Leland Lai, personal communications, December 24, 1991, and February 10, 1992. A recent study by the Universidad Autónoma de Sinaloa concluded that the residues of agricultural pesticides have contributed to the declining catch. "Residuos de Insecticidas son Arrojados al Mar Sinaloense," *Excelsior*, July 23, 1991

13. The cooperatives own some 2,300 shrimp trawlers, many of which are reportedly inoperable or in extremely poor condition. Rosario Gomez, "Refinanciamiento a camaronicultores," *Novedades*, May 8, 1991. As a result, the cooperatives reported problems deploying the vessels when the Pacific season opened on October 5, 1991. Weidner, "Mexican Shrimp Fishermen Seize Local SEPESCA Office," *International Fisheries Report* (IFR-92/21), February 14, 1992; and Weidner, "Mexican Shrimp Fleet Modernization Program," *International Fisheries Report* (IFR-92/37), April 30, 1992.

14. For details on the declining Pacific-coast catch, see Weidner, "Mexico: Sinaloa Shrimp Situation," *op. cit.*; and Weidner, "Sinaloa Shrimp Update," *op. cit.* Some local officials in Sinaloa have suggested that the expanding level of pl collection is affecting the wild catch, though no scientific study substantiates this assertion. Nelly Rejon, "Las Autoridades de Pesca Autorizan en Plena Veda Capturar Larvas de Camarón en Sinaloa: Pérez V.," *Excelsior*, May 11, 1991.

15. Dario Chávez, "Diagnostic de la Pesqueria del Camarón del Pacifico, Temporado 1988-89," *Pesca Industrial*, July 1991. Observers are concerned about fishing in the estuaries, mostly conducted by artisinal fishermen, as well as the collection of pl for stocking ponds. The Government's closed season in the estuaries has been criticized by artisinal fishermen in the state of Oaxaca, who claim the restrictions are unfair and do not address the real causes of reduced wild harvests: pollution from the petroleum industry and corruption and poor administration by the fishing cooperatives and responsible government agencies. Rosa Rojas, "Denuncian los huaves de Oaxaca ante Salinas la imposición de la veda al camarón," *La Jornada*, March 15, 1992.

16. Raúl J. Ramirez, Maquiladora Marina, "Mexican Shrimp Market: A Personal View," *Proceedings: 14th Annual International Seafood Conference*, October 6-9, 1991, Luxembourg, pp. 384-387.

17. Weidner, "Mexican Shrimp Fleet Modernization Program," *International Fisheries Report* (IFR-92/37), April 30, 1992.

SECTION II. (Aquaculture Industry)

18. SEPESCA reported that cultured harvests totaled about 185,000 t in 1988, but this may include substantial freshwater fisheries. SEPESCA, *Anuario Estadistico de Pesca 1988*, April 1990.

19. One report identified 1.3 million ha of inland waters and 1.6 million ha of protected coastal waters which are suitable for aquaculture development. Rosario Gomez, "México se convertirá en dinámico exportador de productos acuícolas," *Novedades*, December 15, 1991; and "Acuacultura, importante alternativa para la pesca en México: Sepesca," *Novedades*, November 28, 1991.

20. A good review of the Government's aquaculture activities and the species being used is available in A. Orbe Mendoza, SEPESCA, "Lineamientos para la investigación en acuacultura," *Los Recursos Pesqueros del Pais*, 1988, pp. 513-520.

21. Gomez, *op. cit.*, December 15, 1991.

22. See for example, Hugo Garcia Michel, "La acuacultura en Baja California, *Técnica Pesquera*, January-February 19988, pp. 12-15; and Weidner, "Mexican Baja Cooperatives," *International Fisheries Report* (IFR-91/23), March 29, 1991.

23. Gustavo de la Rosa Ruíz and Vicente Tapia Verduzco, "Camarón que no madruga ...," *Panorama Pesquero*, September/December, 1991, p.34.

24. SEPESCA, *Anuario Estadistico de Pesca 1988*, *op. cit.*

25. The authors use the definition for aquaculture employed by the FAO in its statistical systems.

26. FAO, "Aquaculture Production (1986-89)," *FAO Fisheries Circular*, No. 815, Rev. 3, July 1991, p. 113. FAO may be underestimating the cultured harvest. Information on aquaculture is limited and various Mexican observers would describe some of the operations harvesting substantial quantities of tilapia could be described as extensive aquaculture operations. Much of this harvest, however, is not included in the FAO aquaculture estimate.

27. Gomez, *op. cit.*, December 15, 1991.

28. The most important portions of the Mexican aquaculture harvest are oysters and shrimp, but small quantities of carp, trout, catfish, tilapia, are also harvested.

29. *Novedades*, November 8, 1990.

SECTION III. (Species)

30. Further biological details on individual species are available in Weidner, Revord, and Wells, "Latin American Shrimp Culture, 1990-2000," *International Fisheries Report*, in press.

31. Bob Rosenberry, *World Shrimp Farming*, May 1990.

32. The most extensive Latin American trials of different species have been conducted by Brazilian farms. Limited success has been reported with several species, but the continuing small Brazilian harvests suggest that growers still have problems with many of them. Weidner, "Brazilian Shrimp Culture," *International Fisheries Report* (IFR-90/92), December 21, 1990.

33. A good review of the Mexican research effort on Pacific shrimp is available in A. Hernandez Carballo, SEPESCA, "Camarón del Pacifico: programa de actividades y vinculación interinstitucional," *Los Recursos Pesqueros del Pais*, 1988, pp. 303-312.

34. At least one institution, the Centro de Investigaciones Biológicas (CIB) in La Paz, Baja California Sur, has begun to investigate the factors which might limit the growth of *P. californiensis* in ponds. Ramon Casillas Hernandez, Guillermo Portillo Clark and Francisco J. Magallon Barajas, "Differences in growth observed in small juvenile *Penaeus californiensis* between laboratory and coastal environments," *Program & Abstracts, 22nd Annual Conference & Exposition of the World Aquaculture Society*, June 16-20, 1991, p. 21; Humberto Villarreal and Richard Hewitt, "Effect of salinity on the oxygen consumption and growth of *P. californiensis*," *Program & Abstracts*, *op. cit.*; Villarreal and Lucia Ocampo, "Effect of size and temperature on the oxygen consumption of *P. californiensis*," *Program & Abstracts*, *op. cit.*; and Villarreal, María C. Rivera and Alma Millan, "Effect of the substitution of shrimp meal for red crab meal in the growth of juvenile *P. californiensis*," *Program and Abstracts* , *op. cit.*

35. Various studies have been conducted to assess the aquaculture potential of *P. stylirostris* in Mexico. The University of Sonora's Centro de Investigaciones Científicas y Tecnológicas (CICTUS), located in Hermosillo, has produced a number of technical reports as well as more general guides for culturing the species. The Centro de Investigación Científica y de Educación Superior de Ensenada, Baja California (CICESE), and the Autonomous University of Baja California Sur's Centro de Investigaciones Biológicas (CICIMAR), located in La Paz, have also contributed research. Universidad Nacional Autónoma de Mexico, Centro de Información Científica y Humanistica, *Aquila Siriac: Directorio 1989*, 1989.

36. For details, see Weidner, "Honduran Shrimp Culture," *International Fisheries Report* (IFR-91/21), March 29, 1991; and Weidner and Revord, "Panamanian Shrimp Culture," *International Fisheries Report* (IFR-91/94), December 27, 1991.

37. At least one group has investigated the suitability of *P. stylirostris* for culture operations in arid conditions. Alfredo Hernandez, Jose L. Hernandez and Martin Gonzalez, "Growth and survival response of *Panaeus stylirostris* stocking densities in a semiarid region of the northwest of Mexico," *Program & Abstracts*, *op. cit*.

38. William Neff, Vice-President, Transpacific Seafood, personal communications, July 12, 1990.

39. One observer reports that feed with 40 percent protein content is required. José Luis Gutierrez, Banco Somex de México, personal communication, August 9, 1990.

40. For more details, see Weidner, Revord and Wells, "Latin American Shrimp Culture, 1990-2000" *op. cit.*

41. The authors have obtained varying reports on Mexican restrictions. Some suggest that the Government is enforcing very stringent regulations prohibiting the use of *P. vannamei* along the Gulf/Caribbean coast. Other reports indicate that farms in Tamaulipas are being allowed to use *P. vannamei.*

42. A good general overview of the Gulf shrimp resource is available in K. Smith, SEPESCA, "Grado de conocimiento del recurso camarón del Golfo de Mexico, una perspectiva en la ocasion del 25 aniversario del Instituto Nacional de Mexico," *Los Recursos Pesqueros del Pais*, 1988, pp. 399-420.

43. A good description of the Gulf stock off Tamaulipas and Veracruz is available in R.G. Castro M., M. Medellin A., E. Rosas Torres, R. Orta Nunez, E. Conde Galaviz, SEPESCA, "Analisis poblacional del recurso camarón en el noroeste del Golfo de Mexico," *Los Recursos Pesqueros del Pais, op. cit.* , pp. 172-177.

44. L.B. Holthius, Food and Agriculture Organization of the United Nations, Rome, *FAO Species Catalogue: Shrimps and Prawns of the World* (FIR/S125 Vol. 1), 1980.

45. A. Bolongaro Crevenna, E. Vasquez, A. Sánchez, and C. Rosas, UNAM, "Crecimiento, sobreviviencia, amplitud metabolica y acción dinamica especifica aparente de postlarvas epibenticas de *Penaeus aztecus* en un sistema experimental de cultivo," paper presented at the II Congreso de Ciencias del Mar, June 18-22, 1990, Havana, Cuba.

46. Holthius, *op. cit.*

47. Weidner, "Brazilian Shrimp Culture Industry," *op. cit.*

48. Holthius, *op. cit.*

49. An excellent review of existing knowledge of freshwater shrimp in Mexico is available in A.A. Granados Berber, "Biologia, ecologia y pesqueria de los langostinos de México," *Univ. Cienc.*, Vol. 1, No. 1, 1984, pp. 5-23.

50. G. Malagrino Lumare, "Monografia sobre el langostino (*Macrobrachium sp.* Bate)," *Revista Investigación Científica Universidad Autónoma Baja California Sur (serie Científica Marina)*, Vol. 1, No. 1, 1988, pp. 9-26.

SECTION IV. (Growing Conditions)

51. Pedro G. Sáenz M. and Francisco Magallón B., Instituto Nacional de Pesca, "Analisis de las posibilidades del cultivo del camarón en el pacifico mexicano," *Documentos de Trabajo*, Vol. 1, No. 7, September 1989.

52. Water temperature data is estimated from sea surface temperature maps provided by the Climate Analysis Center of the National Weather Service, National Oceanic and Atmospheric Administration (NOAA). Large areas of the Mexican coast seem to have less favorable sea surface temperatures than other Latin American countries. (See appendices C1-3.)

53. The experience of the CICTUS operation in Puerto Peñasco, Sonora, indicates that shrimp could be cultured in the northern states, but that lower winter temperatures could prevent growout ponds from being used throughout the year. The Puerto Peñasco operation faced variations in temperature of as much as 25°C. This means that northern farmers would be able to achieve fewer crops per year than growers in tropical countries. Various methods can be employed to make fuller use of the ponds in colder climates, such as raising pl to the juvenile stage in protected heated environments. All such methods, however, entail added costs not faced by growers in warmer climates, a potentially significant competitive disadvantage.

Desert conditions with less than 25 centimeters (cm) of precipitation annually present further problems. Pedro G. Sáenz Martínez and Francisco Magallón Barajas, Instituto Nacional de la Pesca, SEPESCA, "Analisis de las Posibilidades del Cultivo de Camarón en el Pacifico Mexicano," *Documentos de Trabajo*, Vol. 1, No. 7, September 1989.

54. Water temperatures are important because *P. vannamei*, the Latin American species most suited to pond culture, is a tropical species and grows best in water temperatures of 25° C or above. (See Section III. Species.) Growth slows dramatically when temperatures fall below 23° Celsius. Significant die-off can also occur if water temperatures drop even for brief periods during winter cold snaps.

55. Some information on Sinaloan conditions is available in A. Pares Sevilla, "Panorama actual de la camaronicultura en Sinaloa," *Acuavision*, Vol. 3, No. 13, 1988, pp. 4-7.

56. Water temperatures in the extensive mangrove areas of Teacapán region appear to be only slightly lower than in Ecuador. The similarity of temperatures in southern Sinaloa to those in Ecuador suggests that water temperatures may not be a significant impediment to the growth of the industry in the state (appendices C1 and C3). However, occasional temperature drops, which can occur in northern Mexico (from central Sinaloa north), can be an obstacle to shrimp culture. Drops in water temperature of as little as 0.5° C below normal have been shown to have a major impact on growth rates and wild seedstock supplies in Ecuador.

57. Neff, *op. cit.*

58. Growers in neighboring Guatemala are reporting considerable success in developing a shrimp culture industry. See Weidner and Revord, "Guatemalan Shrimp Culture," *International Fisheries Report* (IFR-91/92), December 20, 1991.

59. Weidner, "Mexican Shrimp Culture: Chiapas," *International Fisheries Report* (IFR-89/68), August 11, 1989.

60. Weidner and Revord, "Guatemalan Shrimp Culture," *op. cit.*

61. Michael Autrand, France Aquaculture, personal communication, April 24, 1991.

62. Salinity levels as high as 45 parts per thousand were encountered. Many of the areas investigated had irregular connection to the ocean and thus salinity varies from highly saline in the dry season to virtually freshwater during the rainy season. As a result, one observer notes that contrary to appearances, good sites are rare and the potential area limited in the states of Chiapas and Oaxaca. He recommends that any aquaculture project in the region should be preceded by a complete study of the physical and environmental conditions on the proposed site, carried out over a period of several months. Autrand, *op. cit.*

63. Russ Miget, Texas A&M University, Sea Grant Program, personal communication, May 24, 1991.

64. The number of operational farms along the Atlantic coast (Gulf of Mexico/Caribbean) appears to have declined. (See Section IX. Farms and Farm Ownership.) The decline suggest that growers are encountering significant problems, which may include environmental and physical difficulties. At least one observer, however, believes that the primary problem is financing. Ramirez, *op. cit.*, p. 385.

65. With tidal ranges of only 0.5 meter, farmers may need to rely heavily on pumping to achieve acceptable water exchange rates. Durwood Dugger, Cultured Seafood Group, personal communication, May 24, 1991.

66. Caribbean./Atlantic-coast growers in Colombia and several individual farmers in other countries are reporting success, especially when they have been able to obtain *P. vannamei* postlarvae. For details, see Weidner and Revord, "Colombian Shrimp Culture," *International Fisheries Report* (IFR-91/90), December 15, 1991.

67. Ramirez, *op. cit.*, p. 385.

68. See Weidner and Revord, "Colombian Shrimp Culture," *op. cit.*

69. U.S. growers report that temperatures along the Texas coast are close to permitting two crops per year. T.M. Samocha, F.L. Castille, A.L. Lawrence and S.E. Talley, "Early spring growth trial of Penaeid shrimp postlarvae at high stocking densities in raceways," *Program & Abstracts*, *op. cit.*, p. 56. The slightly warmer conditions only a small distance to the south in Mexico could make a very significant difference in growout operations. Jack Boettcher, Texas General Land Office, personal communication, May 20, 1991. The potential in Tamaulipas and Veracruz, however, has to date not been as thoroughly tested as in Texas. Details on groups in Texas culturing shrimp are regularly reported in *World Shrimp Farming.*

70. Some observers feel that there are many possible sites along the Atlantic (Gulf of Mexico/Caribbean) coast, perhaps even more than along the Pacific. Dugger, *op. cit.*, May 24, 1991. Other observers do not agree. SEPESCA estimates of the potential area for shrimp culture in Tamaulipas, and other states on the Gulf of Mexico and Caribbean, do not approach the potential estimated for any one of several Pacific coast states. (See Section V. Pond Area and appendix D1.)

71. Dugger, *op cit.*, May 24, 1991; and Miget, *op. cit.* One observer notes that sites located in small bays and enclosed estuaries would be appropriate for a few farms, but that a greater number could cause significant problems as a result of the volume of effluent. (See Section IV. Growing Conditions B. Water Quality and Pollution.) Dugger, *op. cit.*, May 24, 1991.

72. The project is reportedly an "intensive" farm, though the stocking densities employed of 12 pl/m^2 were more appropriate to semi-intensive operations. (See Section XI. Methods/Yields.) Shrimp were grown-out in two round ponds of 0.2 and 5.0 ha over a period of 4 months beginning in June 1990. Water conditions and feeding rates were closely watched and controlled, using pumping, aeration, and commercial feed. The ponds were drained after Hurricane Gilbert passed through the area, with harvest yields of slightly less than 1 t/ha for both ponds. Denis Ricque, L. Elizabeth Cruz Suarez, Juan Francisco Sanchez Juarez, Linda Cardelli and William Thorton, "An intensive round pond shrimp culture trial on the Mexican gulf coast," *Program & Abstracts*, *op. cit.* The authors have no personal information on these operations, but it is of interest as Mexican regulations make it very difficult to use Pacific species like *P. vannamei* in Gulf growout operations.

73. The Universidad Autónoma de Campeche (UAC) created the Programa Ecología, Pesquerías y Oceanografía del Golfo de México (EPOMEX) in 1990 to further the "protection and evaluation of the coastal ecosystems and their renewable biological resources." EPOMEX plans to offer a wide array of technical and scientific services as part of its program of coastal ecology research. Tirso R. de la Gala Guerrero, Rector, UAC, "Editorial," *Jaina: Boletín Informativo*, Vol. 1, No. 1, July-September, 1990.

74. The legal status of the mangrove area is often murky and one U.S. grower has spent more than a year trying to purchase a small site.

75. Severno Jose Gongora Barbosa, SEPESCA, Delegado Federal, personal communication, May 12, 1992.

76. Centro de Investigación y de Estudios Avanzados del IPN, unpublished report, 1991.

77. Gonzora, *op. cit.*

78. Francisco Xavier Soto Gonzalez, Director, Centro Regional de Investigación Pesquera, Yucalpeten, personal communication, May 14, 1992.

79. Gongora, *op. cit.*

80. Carlos E. Cabrera-Hidalgo, Project Supervisor, NOVUM, personal communication, March 15, 1991. The project was promoted by a former governor of Campeche, but state funds supporting the project were cut when a new governor was elected. Two small *ejido* groups, however, harvest small quantities in esturine operations. Margarita Rosa Rosado, Subsecretaria de Programación y Apoyo Externo al Desarrollo, personal communication, May 7, 1992. One local observer reports that the Campeche farm was poorly designed and constructed.

81. Weidner, "Mexican Fisheries: Yucatán," *International Fisheries Report* (IFR-92/22), February 7, 1992. Construction was delayed in late 1991, but the owner has obtained the needed funding to finish the first stage of the project in early 1992. Manuel Martinez de A. Beytia, Administrador Unico, Industrias Acuicolas del Golfo, personal communication, May 14, 1992.

82. Farms have been built in Belize which borders Quintana Roo. For details, see Wells and Weidner, "Belize Shrimp Culture," *International Fisheries Report*, in press.

83. Darryl E. Jory, Rosenstiel School of Marine and Atmospheric Science, University of Miami, personal communication, February 27, 1992. Another observer reports problems with land tenure, but is convinced that sites with appropriate conditions can be found. John Mayes, personal communication, May 10, 1992.

84. For a general assessment of how pollution is affecting the capture fishery, see Susana Gutiérrez Arcos, *et. al.*, "Contaminación, Impacto Ambiental y la Producción Pesquera," *Los Recursos del Mar y la Investigación*, 1987. One group, EPOMEX, is just beginning to develop studies on the extent of pollution in the Gulf of Mexico and its environmental impact. EPOMEX's quarterly publication, *Jaina*, has targeted the Gulf coast habitat as a major topic. Alejandro Yáñez-Arancibia and José Luis Rojas Galaviz, "El Golfo de México: Una Prioridad Nacional," *Jaina*, *op. cit.*, July-September 1990; and "Golfo de México Contaminación e Impacto Ambiental: Diagnóstico y Tendencias," *Jaina*, Vol. 2, No. 3, July-September 1991.

85. See for example, Enrique Salazar, "31 cuencas hidrológicas, gravemente contaminadas por desechos tóxicos industriales, reconoce SEDUE," *El Financiero*, December 24, 1991.

86. Patricia Saad, "SEDUE elaborará un programa anticontaminante para el agua," *El Financiero*, December 24, 1991.

87. The Mexican press and other observers have expressed concern about the both Gulf of Mexico, as a result of oil exploration and drilling, and the Gulf of California, which is vital to Mexico's fishing industry. "Contaminado el 80% de los recursos marinos del Golfo de México," *El Nacional*, July 15, 1990; "Podría perderse ecológicamente el Golfo de California," *El Nacional*, September 7, 1989; and Pat Pace, Owner, Pace Fish Company, "Observations," presented at the U.S.A.-Mexico Fisheries Cooperation Talks, September 25, 1991. See also "Pescadores ribereños, afectados por derrames de petróleo y de azufre," *La Jornada*, January 31, 1990; "Recolectó la Armada de México mil 200 toneladas de sustancias tóxicas del mar," *Excelsior*, March 26, 1991; "Residuos de Insecticidad son Arrojados al Mar Sinaloense," *op. cit.*; and Susana Gutiérrez A., *op. cit.*

88. "Se Extinguen los Peces 'Sembrados' en la Presa El Caracol, de Guerrero," *Excelsior*, November 14, 1990.

89. SEDUE charged in June 1988 that of the 53 farms operating along the Sinaloa coast, only 3 had met the technical requirements to protect mangroves. SEDUE warned that the continued "irrational" development of aquaculture, and the resulting destruction of the "ecological equilibrium," could render areas of Sinaloa worthless for cultured production. "La explotación irracional de la acuacultura provocará desequilibrio ecológio: SEDUE," *Excelsior*, June 12, 1988. Mexican officials are concerned about the possible impact of a major shrimp culture industry on the mangrove system. The Program for Ecology, Fisheries, and Oceanography for the Gulf of Mexico (EPOMEX) is publishing a compendium of research studies describing mangrove forest systems and the impact of mariculture and other economic activities. Alejandro Yáñez-

Arancibia, "Mangrove Ecosystems in Tropical America: Structure, Function, and Management," *Serie Científica*, EPOMEX/IUCN Regional Wetland Program for Central America, 1991.

SECTION V. (Pond Area)

90. *Caribbean Aquaculture Association Newsletter*, Summer 1990.

91. SEPESCA, *El Cultivo de Camarón en Mexico y la Participación de FOPESCA*, 1990; and Ignacio Galnares Meza, personal communication, February 26, 1991.

92. Some observers may be reporting operational ponds while others may be reporting the total area constructed and/or under construction. (See appendix D2.)

93. SEPESCA, *Inventario Nacional de Unidades de Producción Acuícola*, 1990.

94. Edgardo Hicks, U.S. Embassy, Mexico City, personal communication, May 16, 1991.

95. Bob Rosenberry, *World Shrimp Farming*, May 1990.

96. Hicks, *op. cit.*, August 8, 1990.

97. A good 1988 assessment of the pond area and site selection in Sinaloa is available in Pares, *op. cit.*

98. Antonio Parez, Biologist, Sinaloa Delegation, SEPESCA, personal communication, August 9, 1990.

SECTION VI. (Pond Harvests)

99. José Luis Gutierrez, *op. cit.*, July 9, 1990.

100. Pares, *op. cit.*

101. Precise data on more recent harvests has been difficult to obtain. SEPESCA released data for 1990 cultured shrimp harvests of 4,950 t in 1990 and 4,989 t on 1991. SEPESCA, Registro Pesquero Informatica y Estadistica, preliminary data, April 1992, received from Edgardo Hicks, personal communication, April 28, 1992. These numbers do not match what SEPESCA officials estimated for Sinaloa's 1990 cultured shrimp harvest of 4,900 tons, which implied a harvest of about 6,000 t for the country as a whole, since Sinaloa accounts for approximately 80 percent of Mexico's cultured shrimp production. The 6,000 t estimate appears somewhat high, however, as other sources have since placed the country's 1990 harvest at just over 5,000 tons. "Shrimp Surge in Mexico," *Fish Farming International*, October 1991.

102. One observer reported that only about 20-25 percent of Mexico's completed shrimp ponds were stocked and operational in August 1990 because of pl shortages. Hicks, *op. cit.*, August 17, 1990. This estimate appears very low. The authors have no other estimates to confirm Hicks' estimate, but some sources do report that large numbers of ponds were idle. While pl supply is a serious problem, the number of idled ponds may actually reflect the large number of poorly designed cooperative ponds which have been abandoned.

103. "Shrimp surge in Mexico," *op. cit.*

104. Details on Ecuadorean shrimp culture are available in Revord and Weidner, "Ecuadorean Shrimp Culture," *op. cit.*

105. See for example, R. Villaseñor Talavera, Universidad Autónoma de Nayarit, "Prototipo biotecnoeconomico para cultivo de langostino *Macrobrachium rosenbergii* en la planicie costera frente al Golfo de México," paper presented at the II Congreso de Ciencias del Mar, June 18-22, 1990, Havana, Cuba.

106. One FAO report indicates that only a small portion (perhaps 10 percent) of Mexico's freshwater shrimp harvest comes from pond culture. FAO, "Una estrategia para el desarrollo de la acuicultura: el caso de América Latina," *COPESCAL Documento Ocasional*, OP 6, Rome, 1990.

107. Unlike marine shrimp, private investors were not prohibited from culturing freshwater shrimp. (See Section VII. Legal and Social Framework.)

108. SEPESCA, *Anuario Estadistico de Pesca 1986*, April 1988.

109. SEPESCA, *Anuario Estadistico de Pesca 1988*, April 1990.

110. Other important regional producers are Brazil, the Dominican Republic, and Puerto Rico.

SECTION VII. (Legal and Social Framework)

111. The Administration of President Miguel Alemán was the first to designate reserved species in 1950.

112. Mexican press reports indicate that some important ports have only about one-third the number of vessels operating in 1991 as compared to 1981, when the Government forced all remaining private vessel owners to sell their shrimp trawlers to the cooperatives. Mexico's wild fishery has declined steadily since the mid-1980s. (See Section I. Capture Fishery.) Mexican officials cite a variety of causes for the decline, including unfavorable climatic conditions and poaching in the estuaries, but one major cause is cooperative mismanagement, especially the deteriorating condition of their fleet. Gomez, "Refinanciamiento a camaronicultores," *op. cit.*; Oscar Camacho Guzmán, "Embargos y quiebra amagan a cooperativas pesqueras," *La Jornada*, June 19, 1991; and Weidner, "Mexico Studies Shrimp Industry," *NMFS Weekly Highlight*, July 26, 1991. The Government is now planning a major program to replace derelict vessels with 300 new vessels over the next 3 years (1992-94). Weidner, "Mexican Shrimp Fleet Modernization Program," *op. cit.*

113. Camacho, *op. cit.*

114. Moreno adds that restructuring the cooperative system will not be an easy task. Jesus Murguia Rubio, "Sólo funcionan bien la mitad de las cooperativas pesqueras," *El Nacional*, February 21, 1992.

115. Luis Castillo, "Operan con irregularidades 25% de las 1,625 cooperativas pesquera del país: Mendoza R.," *Excelsior*, December 3, 1991.

116. Cooperative leaders dispute this charge, but requests by the authors for their assessment of the 1980s experience have gone unanswered.

117. Mexico's newly appointed fishery officials are currently conducting an assessment of the country's deteriorating shrimp industry. SEPESCA has already approved an expanded role for private investors. The Government is unwilling to finance another major credit program to bail out the cooperatives and is instead encouraging private investors and cooperatives to work our mutually beneficial arrangements. More than 200 privately owned vessels have been deployed through the new cooperative leasing arrangements. Accepting these arrangements was a major concession by the cooperatives which had for years lobbied the Government to prohibit private sector shrimping. Gomez, "Participará la IP en la explotación de especies marinas in altamar: GJM," *Novedades*, June 20, 1991; and Weidner, "Mexico Studies Shrimp Industry," *op. cit.*

118. "Dependerá de los sectores privado y social la producción camaronera," *Novedades*, July 29, 1991.

119. For a description of one such incident, see Weidner, "Mexican Shrimp Fishermen Seize Local SEPESCA Office," *op. cit.*

120. For further details on the proposed changes, see Weidner, "Mexico: New Fisheries Law," *International Fisheries Report* (IFR-92/46), June 15, 1992.

121. Aquaculture is a relatively new industry in many Latin American countries, and as a result governments are just beginning to develop a regulatory framework. A good review of the potential government concerns and regulatory frameworks has been prepared by the United Nations Food and Agriculture Organization (FAO). See Anne R. Houtte, Nicola Bonucci, and William R. Edeson, "A Preliminary Review of Selected Legislation Governing Aquaculture," *Aquaculture Development and Coordination Programme Report*, ADCP/REP/89/42, Rome, 1989.

122. Mexico's principle fisheries law is the *Ley Federal de Pesca*, together with associated *Reglamento de la Ley Federal de Pesca*. Major revisions in 1986 and 1989 affect the legal basis for farming shrimp. See "Decreto que Reforma, Adiciona y Deroga Diversas Disposiciones de la Ley Federal de Pesca," *Diario Oficial*, México, D.F., December 30, 1989; and "Decreto que Modifica el Reglamento de la Ley Federal de Pesca," *Diario Oficial*, México, D.F., February 7, 1991.

123. *Ejidos* are the agrarian communities established since the 1930's as part of Mexico's land reform program. Community members are referred to as *ejiditarios*.

124. Weidner, "Latin American Shrimp Culture Industry, 1986-90," *International Fisheries Report* (IFR-88/38), May 3, 1988.

125. One report identified the "deficient internal administrative organization" of the social sector in attempting the change from fishing to culture. SEPESCA, *El cultivo de camarón en Mexico, op. cit.*

126. Weidner, "Latin American Shrimp Culture," *op. cit.*

127. One 1991 report suggested that the debt of the fishery cooperatives totals about $130 million. Ignacio Herrera A., "Están despojando de sus bienes de producción al cooperativismo pesquero," *Excelsior*, December 16, 1991.

128. This provision was intended to prevent unscrupulous speculators from taking advantage of the unsophisticated *ejiditarios* and to assure that the land would be available for future generations. The prohibition against selling or using these lands as collateral has restricted an essential ownership right, however, and leaves the ejido members as rent-free tenants--unable to benefit from the significant market value of their lands.

129. President Salinas has obtained Congressional approval for constitutional changes permitting individual *ejiditarios* to buy their land. Initial reports indicate that the land once purchased could be rented, mortgaged or sold outright under the normal investment rules prevailing throughout the economy. While details are not yet available, this change could have a major effect on Mexico's shrimp culture industry by opening large areas of coastal land which heretofore have been off-limits to private investment. Edward Cody, "Mexico to Revise Concept of Agrarian Ownership," *Washington Post*, November 8, 1991, p. A27; and Nancy Cleeland, "Law to End Land Reform in Mexico," *San Diego Tribune*, November 8, 1991. The amendments were passed by Congress in early 1992.

130. Weidner, Revord, and Wells, "Latin American Shrimp Culture, 1990-2000," *op. cit.*

131. One observer, Roberto Grecko, disputes the lack of progress and the conclusion that cooperatives have failed to develop the country's shrimp culture potential. Roberto Grecko, "Editorial," *Linea Cooperativa*, January/February 1990. The authors have made repeated attempts to elicit more specific comments and data from Mr. Grecko and other cooperative officials, but they have declined to provide their assessment of the cooperative effort to culture shrimp.

132. The program reportedly financed the construction of more than 4,000 ha of ponds, while providing assistance to some 50 farms between 1988 and 1990. Participating farms also reportedly achieved an average yield per cycle of nearly 1 ton. SEPESCA, *El cultivo de camarón en Mexico, op. cit.*

133. SEPESCA, *Programa Nacional de Cultivo de Camarón*, October 1987.

134. Almost all shrimp culture projects were traditional cooperative farms as recently as 1986. In only a few years, however, there has been a substantial shift in the industry, as private groups formed the special cooperatives permitted by the 1986 amendments. One observer reported that by 1988, about 40 percent of the shrimp farms in the state of Sinaloa (where the industry is centered) were owned by cooperatives established by family groups and other private individuals. "Cultivo de Camarón," *Pesca*, November-December 1990.

135. SEPESCA, *Sector Agroindustrial: Camarón de Aquacultura*, 1988.

136. For a detailed discussion of the issues surrounding the 1990 revisions, see Dennis Weidner and Randolf Wells, "Mexican Shrimp Culture: Legal Changes," *International Fisheries Report* (IFR-91/22), March 31, 1991.

137. Introduction to the *Ley Federal de Pesca 1990, op. cit.*

138. *Ley Federal de Pesca 1990, op. cit.*, Article 24; and *Caribbean Aquaculturist*, April 1990.

139. "Shrimp Surge in Mexico," *op. cit.*; and Julio Morales, "Es Acertada la Aperatura del Sector Pesquero al Capital: Cabrera Toledo," *Excelsior*, April 30, 1991.

140. The Government had restricted all private investment, both domestic and foreign, in marine shrimp culture. Now that private investment in shrimp farms is allowed, the general requirement of majority ownership by Mexican citizens applies. The Governments of Presidents De la Madrid and Salinas have granted numerous exemptions to this requirement in an attempt to encourage foreign direct investment in various sectors of the economy, especially those with a significant export potential. The requirement for majority Mexican ownership, however, is strengthened by similar provisions specifically applied to the fisheries sector by the *Ley Federal de Pesca*. To date, foreign investors in the fisheries sector (including aquaculture) have obtained exemptions from the majority ownership rule only in the processing sector. The Government in 1991 announced plans to open aquaculture to majority foreign-ownership, but has not yet issued the necessary implementing regulations. Foreign investment regulation will be one of the issues discussed by Mexico and the United States in the upcoming North American Free Trade Agreement (NAFTA) talks.

141. Neff, *op. cit.*, and Hicks, *op. cit.*, July 17, 1990.

142. Durwood Dugger, "Understanding Shrimp Aquaculture in Mexico: Yesterday, Today, and Tomorrow," *Aquaculture Magazine*, July/August 1990.

143. "Decreto que Modifica el Reglamento de la Ley Federal de Pesca," *Diario Oficial*, México, D.F., February 7, 1991.

144. For aquaculture projects carried out on private, ejido, or communal lands, the regulations indicate that no Government concession is required. Many operating farms currently do not have a concession. (See Section X. Farms and Farm Ownership.) SEPESCA continues to insist, however, that for reserved species (which include shrimp) the issuance of a concession is required when waters under federal jurisdiction are used. Weidner and Wells, "Mexican Shrimp Culture: Legal Changes," *op. cit.*

145. See Revord and Weidner, "Ecuadorean Shrimp Culture," *op. cit.*

146. "Inauguró la SEPESCA en Mazatlán un centro para investigar y proteger a tortugas marinas. Se apoyará la camaronicultura con 180 mil millones," *Uno Mas Uno*, December 7, 1991, p. 18.

147. Even before SEPESCA issued detailed regulations, local observers reported that the process of purchasing pl was awkward and time consuming. At times, the cooperatives were unable to supply the berried females and postlarvae. This led to periodic seedstock shortages. In August 1990, for example, observers reported large numbers of unstocked ponds. One observer reported that only 1,000 ha of the country's approximately 5,000 ha of ponds were stocked and operational. The problem was at least temporarily resolved in early August 1990, when the fishing cooperatives agreed to allow shrimp farmers and hatchery operators to collect their own pl and gravid females, though SEPESCA officials have not verified this. Regulations issued in March 1991 appear to expressly forbid such an arrangement: "The collection of shrimp larvae and postlarvae must be carried out directly by the members of the permitted cooperatives, ejidos or communal groups." (For more details, see Section XIV. Postlarval Supply.) Hicks, personal communications, August 8, 1990; Jose Luis Gutierrez, *op. cit.*; Parez, *op. cit.*; and SEPESCA, "Acuerdo por el que se regula la recolección de las especies de camarón existentes en el medio natural en los estadios de larvas y postlarvas que se utilicen para el desarrollo de actividades acuícolas," March 1991.

148. Hicks, *op. cit.*, August 8, 1990.

149. SEPESCA, *El cultivo de camarón en Mexico*, *op. cit.*

150. One observer notes that growers must deal with five Federal agencies in order to obtain necessary aquaculture permits. In a conference which President Salinas, cooperative leaders proposed that they be able to obtain all necessary permits from one agency. C. Eduardo Castro, "Impulso a la Acuacultura del Sector Cooperativo Pesquero," *Reunion con el Sector Cooperativo Pesquero*, January 19, 1991.

151. U.S. Consulate, Mazatlán, July 2, 1991.

152. Herrera, "Están despojando," *op. cit.* Herrera's article includes a long interview with Castro Verduzo discussing the current state of the fishery cooperatives.

153. "Mexico frees its farms, too," *The Economist*, November 6, 1991, p. 49.

154. Rosenberry, *World Shrimp Farming*, January-February, 1992; and Cleeland, *op. cit.*

155. José Luis Castro Verduzco, President of the Asociacion Nacional del Sector Social de la Pesca (ANASPE), insists that the Government has already decided to end the reservation of shrimp and other species for the cooperatives as part of SEPESCA's overall efforts to restructure the fishing industry. Ignacio Herrera A., "Desaparecen para el sector social las especies reservadas a las cooperativas," *Excelsior*, December 17, 1991. Fisheries Secretary Guillermo Jiménez Morales, however, has assured the cooperatives that shrimp fishing on the high seas will continue to be reserved to them, although private investors can participate if they form associations with cooperatives. Avelino Hernández Vélez, "Continuará como actividad exclusiva del sector social la captura de especies marinas en altamar," *El Financiero*, October 7, 1991. Secretary Jiménez has indicated, however, a major revision of the legislative framework for fisheries is being prepared. Roberto Fuentes Vivar, "Será modificado el marco jurídico del sector pesquero," *Jornada*, January 4, 1992.

156. For additional information, see Weidner, "Mexico: New Fisheries Law," *op. cit.*

SECTION VIII. (Government Promotional Role)

157. SEPESCA reported total cultured harvests in 1988 of about 185,000 t, but this may include substantial freshwater fisheries. SEPESCA, *Anuario Estadistico de Pesca 1988*, *op. cit.*

158. SEPESCA has recently emphasized the significant investment opportunites in the aquaculture sector and Mexico's human, natural, and technical resources for developing the industry's potential. One report identified 1.3 million ha of inland waters and 1.6 million ha of protected coastal waters which are apt for aquaculture development. Rosario Gomez, "México se convertirá en dinámico exportador de productos

acuícolas," *Novedades*, December 15, 1991; and "Acuacultura, importante alternativa para la pesca en México: Sepesca," *Novedades*, November 28, 1991.

159. *Novedades*, November 8, 1990.

160. SEPESCA, *El cultivo de camarón en Mexico*, *op. cit.*

SECTION IX. (Foreign Participation)

161. Government officials report that this provision may be changed and majority foreign ownership allowed, but to date such changes have not been implemented.

162. Benjamin Ruíz, *op. cit.*

163. Yosuke Hirono, Executive President, PENTEC, personal communication, March 27, 1991.

164. Autrand, *op. cit.*

165. See Fideicomiso Fondo Nacional para el Desarollo Pesquero (FONDEPESCA) and France Aquaculture, *Formulación de Proyectos: Guía para Camaronicultura*, (SEPESCA, Mexico City, 1990); *Manual de Engorda de Camarón: Cultivo Semi-intensivo del Camarón Blanco del Pacifico Mexicano*, (SEPESCA, Mexico City, January 1991); and *Evaluación Financiera de Proyectos en el Caso de la Producción de Postlarvas de Camarón*, (SEPESCA, Mexico City, 1990).

166. "El Grupo Desc Impulsa la Acuacultura," *Financiero*, November 14, 1991; "France Aquaculture au Mexique," *Le Marin*, October 4, 1991; and "French group invests in Mexican shrimp," *Fish Farming International*, September 1991.

167. Hicks, *op. cit.*, August 19, 1991.

168. Lorenzo M. Juárez, personal communication, October 31, 1988. CANASA has since suspended operations in Panama and sold its farms.

169. The projects will reportedly produce about 2.3 billion pl annually when completed. Hicks, *op. cit.*, June 19, 1992.

170. "Trade Expansion Agreement Reached with Mexico" *The Nation*, Bangkok, Thailand, March 10, 1992.

171. Hicks, *op. cit.*, April 14, 1992.

SECTION X. (Farms and Farm Ownership)

172. Jose Luis Gutierrez, *op. cit.*

173. Hicks, *op. cit.*, August 17, 1990; and José Luis Gutierrez, *op. cit.*, August 9, 1990.

174. Parez, *op. cit.*

175. Ricardo Dubost Quijano, Biologist, S.C.P.A. Acuacultores de la Peninsula de Baja California, personal communication, November 12, 1991.

176. SEPESCA, *Boletín de Acuacultura*, February 1988.

177. SEPESCA, *El cultivo de camarón en México*, *op. cit.*; and Galnares, *op. cit.*

178. SEPESCA, *Directorio de Granjas Acuícolas Correspondientes al Area de Los Mochis*, 1990.

179. The use of the term "intensive" should be viewed with some skepticism. The authors do not have access to details on farm operations. The manager may be using the term to differentiate it from low-yield extensive systems. The farm may be better described as semi-intensive.

180. Fernando Pintado, personal communication, October 25, 1991.

181. SEPESCA, *Directorio de Granjas Acuícolas*, *op. cit.*

182. "El Grupo Desc Impulsa la Acuacultura," *op. cit.*

183. Patrick Julian Wood, personal communication, November 19, 1991.

184. SEPESCA, *Boletín de Acuacultura*, *op. cit.*, February 1988.

185. Anezcua, *op. cit.*, July 10, 1991.

186. Additional details are available in a report based on information obtained by the U.S. Consulate in Hermosillo. Weidner, "Mexican Shrimp Culture: Sonora," *International Fisheries Report* (IFR-90/65), September 28, 1990.

187. Robert Witajewski, U.S. Consulate, Hermosillo, personal communication, April 22, 1992.

188. SEPESCA, *Boletín de Acuacultura*, *op. cit.*, February 1988.

189. SEPESCA, *Directorio de Granjas Acuicolas*, *op. cit.*

190. SEPESCA, *Directorio de Granjas Acuicolas*, *op. cit.*

191. Pintado, *op. cit.*

192. SEPESCA, *Boletín de Acuacultura*, *op. cit.,* February 1988 and January 1991.

193. Pintado, *op. cit.*

194. SEPESCA, *Directorio de Granjas Acuícolas*, *op. cit.*

195. SEPESCA, *Directorio de Granjas Acuícolas*, *op. cit.*

196. Pintado, *op. cit.*

197. SEPESCA, *Directorio de Granjas Acuícolas*, *op. cit.*

198. SEPESCA, *El cultivo de camarón en Mexico*, 1990.

199. U.S. Consulate, Mérida, October 10, 1991.

200. Manuel Martinez de A. Beytia, Administrador Unico, Industrias Acuicolas del Golfo, personal communication, May 14, 1992.

201. Efrain Chavez Roman, Administrator, Acuacultores Mar Land, personal communications, January 27 and 28, 1992.

202. SEPESCA, *Directorio de Granjas Acuícolas, op. cit.*

203. SEPESCA, *Directorio de Granjas Acuícolas, op. cit.*

204. Galnares, *op. cit.*, March 1, 1991.

205. Galnares, *op. cit.*, March 1, 1991; and SEPESCA, *Directorio de Granjas Acuícolas, op. cit.*

206. Pintado, *op. cit.*

207. Rosenberry, *op. cit.*, May 1990.

208. SEPESCA, *Directorio de Granjas Acuícolas, op. cit.*

209. "Destaca Jiménez Morales al avance en materia pesquera de Tamaulipas," *Novedades*, November 9, 1991.

210. Jory, *op. cit.*

211. For example, the state of Morelos reports 27 small *ejido* farms operating about 475 rudimentary ponds averaging only 0.1 ha in area. *M. rosenbergii* pl are received from a Government hatchery in Guerrero state, and used in polyculture growout with tilapia. The Morelos freshwater harvest was estimated at 35 t in 1990 and projected at nearly 55 t for 1991.

SECTION XI. (Methods/Yields)

212. Weidner, "Latin American Shrimp Culture Industry, 1986-90," *op. cit.*

213. One 1988 report suggested that 54 of the operational shrimp farms used extensive culture methods, but 20 of the state's 22 farms under construction were semi-intensive operations. The other two farms under construction planned to use what the owners call "intensive" culture methods. Details on the exact nature and design of the farms are not available. Hicks, U.S. Embassy, Mexico City, "Trip Report," July 26, 1988.

214. Margaret Miller, "Shrimp Aquaculture in Mexico," *Food Research Institute Studies*, Vol. 22, No. 1, 1990.

215. Galnares, *op. cit.*, February 6, 1991.

216. One observer reports water exchange rates of up to 10 percent daily. Miller, *op. cit.*

217. Galnares, *op. cit.*, February 6, 1991.

218. José Luis Gutierrez, *op. cit.*, August 9, 1990.

219. The University of Sonora and the Autonomous University of Nuevo Leon have produced studies addressing intensive shrimp culture methods. See G.W. Dioni, CICTUS, "Cultivo intensivo de camarón," Universidad de Sonora; and J.G. Compeán, Facultad de Ciencias Biológicas, "Desarrollo tecnológico de cultivo intensivo de camarón en tanques redondos," Universidad Autónoma de Nuevo Leon.

220. SEPESCA, "El Cultivo de Camarón en Mexico," *op. cit.*

221. Some semi-intensive farms reported low yields, at least in part because they had just opened and were experiencing problems with their preliminary runs.

222. José Luis Gutierrez, *op. cit., August 9, 1990*, and Hicks, *op. cit*, August 17, 1990.

SECTION XII. (Production Costs)

223. In one case, an experimental operation contacted by the authors kept no records at all on costs. Many operations keep only rudimentary records.

224. The Congress amended the Constitution in a 1992 provision concerning *ejido* land holdings. The *ejidos* now will be able to mortgage land to obtain credit. Some may be broken up into private holdings. The full impact of the amendment on the shrimp culture industry, however, is not clear.

225. Hayes, *op. cit.*

226. José Luis Gutierrez, *op. cit.*, April 15, 1992.

227. These figures include only variable costs such as fuel, feed, pl, processing, and taxes, and exclude fixed costs such as construction, land, and financing costs. Miller, *op. cit.*

228. One observer estimates the cost of construction at between $1,000 and $1,400 per ha for an extensive operation, and between $3,800 and $4,600 per ha for a semi-intensive operation. Operating costs range between $680 and $775 per ha for extensive operations, and between $1,900 and $2,200 per ha for semi-intensive operations. Miller, *op. cit.* One SEPESCA report estimates considerably higher costs for both construction (about $9,600 per ha) and operation (nearly $3,500 per ha). SEPESCA, *El Cultivo de Camarón en México, op. cit.*

SECTION XIII. (Research)

229. One recent report listed over 630 aquaculture research studies conducted in Mexico. It also listed Mexican researchers. Some 137 Mexican institutions were listed as sponsoring aquaculture research. In addition to Mexico, the report lists research in six other Latin American countries -- Brazil, Cuba, Mexico, Panama, Peru and Venezuela. The limited number of countries does not permit relative comparisons. Centro de Información Cientifica y Humanistica, *op. cit.*

230. See for example C. Rosas, I. Fernandez, R. Brito, and E. Díaz-Iglesia, (UNAM in Mexico and CIM in Cuba), "Effecto de la ablacion de los pedunculos oculares sobre el balance energetico de *Penaeus notialis*," paper presented at the II Congreso de Ciencias del Mar, June 18-22, 1990, Havana, Cuba.

231. A number of such programs have been held in recent years, such as *Curso Teórico Práctico de Patología de Camarón Cultivado* held in August 1991 in Mazatlán. FAO, *Actividades de Capacitación PRADEPESCA*, September 1991.

232. Biologist García, Barra de Navidad Hatchery, personal communication, July 8, 1991.

233. For details on the Ecuadorean industry, see Revord and Weidner, "Ecuadorean Shrimp Culture," *op. cit.*

234. Centro de Información Cientifica y Humanistica, *op. cit.*

235. Malagrino Lumare, *op. cit.*

SECTION XIV. (Postlarval Supply)

236. Wild pl is available in the estuaries of Sinaloa and other Pacific-coast states. Some observers indicate that *P. stylirostris* is most prevalent in northern Sinaloa, while *P. vannamei* is more prevalent in southern Sinaloa. Rosenberry, *op. cit.*, November 1991.

237. One observer indicated that 1991 permits authorizing the collection of 0.8 billion pl were not issued until July, more than 2 months late. This was especially harmful to northern growers, as any delay in obtaining seedstock reduces their already limited potential growing season. Leland Lai, Aquafauna Bio-Marine, personal communication, February 10, 1992.

238. Hicks, *op. cit.*, June 4, 1991.

239. For details on the Ecuadorean system, see Revord and Weidner, "Ecuadorean Shrimp Culture," *op. cit.*

240. Biologists speculate that wild pl undergo a natural selection process (which eliminates the weaker individuals) to which hatchery pl, spawned and reared in a protective environment, are not subject.

241. Industry observers have noted at least one instance of stocking with imported pl, though such imports are severely restricted under current SEPESCA regulations. One group successfully met the restrictions and recently imported a shipment of postlarvae. The possibility of importing and spreading shrimp diseases is the primary reason for SEPESCA's restrictions on pl imports. One observer notes that disease may well become a major concern of Mexico's developing shrimp culture industry in the future, but as of yet no widespread problems have been reported. Alejandro Flores Tom and Ernesto A. Garmendia Nuñez, "Marine Shrimp Aquaculture in Mexico: Current Status," *Shrimp Culture in North America and the Caribbean*, (World Aquaculture Society, 1991).

242. For a treatment of pl availability in the wild, see R. Baltierra, Centro Regional de Investigaciones Pesqueras, Manzanillo, "Distribución y abundancia relativa de postlarvas de camarón en la Laguna de Cuyutlan, Colima, México;" P.J. Calderón, Instituto de Ciencias de Mar Y Limnología, Universidad Nacional Autónoma de México, "Variación espacial y temporal de la abundancia relativa de postlarvas de camarón *Panaeus sp.* en la Plataforma Continental del Sur de Sinaloa;" C.H.R. Nenninger, Centro de Estudios Superiores de la Universidad de Sonora, "Determinación de los ciclos de abundancia de los camarones del género Panaeus en las costas de Sonora;" and V.F. Tena, Delegación Federal de Chiapas, SEPESCA, "Estudio de la disponibilidad de postlarvas para el cultivo de camarón en la costa de Chiapas," all in Universidad Nacional Autónoma de México, Centro de Información Cientifica y Humanistica, *Aquila Siriac: Directorio 1989*, 1989.

243. Hicks, *op. cit.*, June 4, 1991.

244. Henry Clifford, Tropical Mariculture Technologies, personal communication, June 11, 1991.

245. Sáenz and Magallón, *op. cit.* This report indicated that pl was available in Baja California in February and July, in central Sinaloa between February and November, and in Oaxaca year-round.

246. Flores and Garmendia, *op. cit.*

247. One observer notes that growers in Sinaloa harvest more than two thirds of their annual production during the Fall/Winter season (August through February). Ponds for this season are stocked almost entirely with wild pl, which can be obtained from June through November. Growers stock fewer ponds during the remaining cool months, and must rely on either hatchery pl (which is considerably more expensive than wild pl) or on small amounts of wild pl which have been stored in nursery ponds for use during the off-season. Gutierrez, *op. cit.*, April 15, 1992

248. One observer predicts that pl will be unusually abundant in 1992, the result of warmer temperatures and higher rainfall associated with the El Niño event. Gutierrez, *op. cit.*, April 15, 1992. Growers in Ecuador have long noted the effects of El Niño on their harvests. See Revord and Weidner, "Ecuadorean Shrimp Culture," *op. cit.*

249. Parez, personal communications, August 9, 1990 and Hicks, *op. cit.*, August 8 and August 17, 1990.

250. An industry observer claims that some 90 percent of wild pl has been collected around Cospita, which is located along the central Sinaloa coast near Elota. Growers are now expanding efforts to collect pl outside of Sinaloa, particularly in the states of Nayarit and Chiapas. Gutierrez, *op. cit.*, April 15, 1992.

251. Both cooperatives and *ejidos* may collect pl for their own culture operations. *Ley Federal de Pesca, op. cit.*

252. For details, see Revord and Weidner, "Ecuador Shrimp Culture," *op. cit.*

253. Lai, *op. cit.*

254. One observer reports that the contract to collect pl is currently set at $3 per 1,000, with $2 going to the cooperative and $1 going to SEPESCA. While this would appear to be relatively inexpensive, it does not include the actual costs of collection, such as labor, fuel, boats, etc. In addition, some growers claim that the actual fees may be higher and, at times, arbitrary. Many growers complain that cooperative pl collection is unreliable. Hicks, *op. cit.*, June 4, 1991.

255. One official suggested that increased hatchery production will reduce pressure on wild postlarvae. *Fish Farming International*, September 1989. There is little empirical evidence, however, to support the concern that current pl collection levels will significantly affect wild stocks.

256. Jose Luis Gutierrez, *op. cit.*

257. This is not surprising given the fact that long established hatcheries in Ecuador and other countries continue to report serious problems. Part of the problem is that *P. vannamei* appears to be an especially difficult species with which to work in hatcheries. For details, see Revord and Weidner, "Ecuadorean Shrimp Culture," *op. cit.*

258. An International Symposium on Shrimp Larvae Hatcheries was held in early December 1991 in Mazatlán, Sinaloa, sponsored by SEPESCA. The authors have not yet obtained details on the event, but the program was to include sessions on various technology and systems used in Europe, Asia, and the Americas. D.I. Virginia Gonzalez V., Prodiseño, S.A., personal communication, November 26, 1991.

259. Carlos Cabrera, Novum Corporativo, personal communication, July 16, 1991.

260. "La Producción de Postlarvas de Camarón Azul," *Técnica Pesquera*, March-April 1987.

261. Cabrera, *op. cit.*

262. *El Nacional*, June 11, 1989.

263. Cabrera, *op. cit.*

264. Dubost, *op. cit.*

265. Rosenberry, *World Shrimp Farming*, January/February 1992.

266. Biologist García, Barra de Navidad Hatchery, personal communication, July 8, 1991.

267. "La Producción de Postlarvas de Camarón Azul," *op. cit.*

268. Anezcua, op. cit.

269. Carlos Tobal Flores, CET Biologist, personal communication, July 8, 1991.

270. Carlos Santamaría Ochoa, "Obtienen por primera vez en México el desove de camarón en laboratorio," *El Nacional*, January 14, 1989.

271. Edward Klima, James McVey, and Cornelius Mock, "Trip Report: University of Arizona Research Laboratory at Tucson, Arizona," NMFS trip report, October 31-November 2, 1977.

272. Laura Diamond, "Armed Cadets in; UA Out at Shrimp Farm," *Tucson Citizen*, June 27, 1980 and "Roto Un Convenio sobre Camaronicultura entre Mexico y Estados Unidos," *Tecnica Pesquera*, September 1980.

273. One observer reports that the El Tambor hatchery is receiving no Government assistance, relying instead on commercial bank financing through a regional bank, Banoro. The reported interest rate (100 percent over 2 years) is quite high, even by comparison to other commercial rates in Mexico. Hicks, *op. cit.*, August 19, 1991.

274. Cabrera, *op. cit.*, July 16, 1991; and Hicks, *op. cit.*, August 19, 1991.

275. Caribbean Aquaculture Association, *op. cit.*

276. Only a few *P. brasiliensis* juveniles were being held in one of the tanks and the lab workers indicated they were haveing problems with the electricity supply. Work is also underway on algae and *Artemia* at the Puerto Morelos CRIP to support the hatcheries. Weidner, site visit, May 11, 1992.

277. SEPESCA announced plans to produce white shrimp pl at the Tampico lab and pink shrimp pl at Lerma beginning in 1992, as part of a larger effort to increase shrimp culture on the Atlantic coast. "Desarrollará Sepesca un programa de acuacultura en Yucatán en 1992," *Novedades*, November 19, 1991.

278. A recent press report indicated that SEPESCA would invest more than 250 million pesos to repair and upgrade El Carrizal aquaculture center in Guerrero. Plans call for a production capacity of nearly 34 million freshwater pl annually. "Guerrero: rehabilitarán centro acuícola," *Novedades*, March 3, 1992.

279. Lai, *op. cit.*

280. See for example work on *P. notialis*. Rosas, *et. al.*, *op. cit.* Also see the work conducted at the INP labs on other Atlantic species. Caribbean Aquaculture Association, *op. cit.*

281. See for example, F.A. Abreu-Grobois, R. Briseno-Duenas, M.A. Herrera, and M.L. Malagon, "A model for growth of *Artemia franciscana* cultures based on food ration dependant gross growth efficiencies," paper prepared at the Estación Mazatlán, Instituto de Ciencias del Mar y Limnologia, UNAM, and presented at the Euphyllopod Symposium, Ghent, Belgium, August 9-12, 1989 and Alberto Grobois, ICM/UNAM, "Computer Based Population Modelling," *Artemia Newsletter*, April 1988, pp. 49-64.

282. The Universidad Autónoma Metropolitana (UAM) at Xochimilco began its research program in 1980 and has been especially active in this area. "*Artemia* research in Mexico," *Artemia Newsletter*, October 1986, pp. 12-13. The INP at its Yucalpeten and Puerto Morelos CRIPs is also working on artemia. Soto, *op. cit.*, and Mariana Trejo, Puerto Morelos CRIP, personal communication, May 11, 1992.

283. "San Francisco Bay *Artemia* Inoculation in Mexico," *Artemia Newsletter*, No. 13, August 1989, p. 5.

284. A.A. Ortega and A. Martinez G. "Hydrological and population studies on *Artemia franciscana* in Yavaros, Sonora, Mexico," *Artemia Newsletter*, No. 11, January 1989, p. 30.

285. "Nueva empresa produce *Artemia* como alimiento para la acuacultura," *Técnica Pesquera*, November-December 1986, p. 3.

286. An *ejido* is reportedly producing small quantities of *Artemia* at Koholoche in Yucatán. M. Olguin Palacios, "Cultivo semintensivo de *Artemias* en Koholoche, Yucatán, México," paper presented at the II Congreso de Ciencias del Mar, June 18-22, 1990, Havana, Cuba. The Industria Salinera de Yucatán (ISY) is reportedly planning to prepare a 1-ha pond at its Colorados salt production facility. For details, contact Edgardo Rode Diaz, ISY.

287. The 1.5 billion pl estimate is based on SEPESCA calculations. Rejon, *op. cit.* and Hicks, *op. cit.*, June 4, 1991. The hatchery estimate is based on data compiled by the authors (appendices I1 and I2).

288. The authors know of only one group which has imported postlarvae. Mexico has strict regulations to protect indigenous stocks from exotic infectious pathogens. Thus, obtaining the many necessary import permits requires certification that the organisms to be imported are specific pathogen free (SPF), an extremely complicated administrative process.

289. "Creciente demanda: Insta SEPESCA a invertir en granjas de camarón," *Jornada*, December 2, 1991.

290. Other observers estimate lower pl demand. Rough calculations based on the 1990 harvest suggest pl demand of perhaps 0.4 billion. Assuming an average cultured shrimp size of 21 grams (equivalent to the 31-40 count shrimp which dominate harvests), there would be about 48 shrimp per kilogram, or 48,000 per ton, which comes to 262 million for a 5,500 t harvest. Assuming a 70 percent pond survival rate, farmers would have needed approximately 375 million pl for the year to stock ponds.

291. One observer estimates that as much as 70 percent of the total pond area was unstocked in late 1990 and early 1991. Hicks, *op. cit.*, June 4, 1991. The authors cannot confirm such a high rate of idled ponds, but other sources do confirm a substantial number of unstocked ponds. It is likely that in addition to scarce pl, idle ponds were due at least partially to the large area of poorly managed, and often badly designed, cooperative ponds, some of which were abandoned.

292. SEPESCA officials confirmed this analysis in late 1991, indicating that the production of wild and hatchery seedstock continues to be insufficient. The Director General for Aquaculture, Rubén Ocaña Soler, hopes that private investors will alleviate the shortage by financing additional hatchery projects. Ignacio Herrera A., "La Acuacultura Camaronera, en Peligro de Detenerse: SEPESCA," *Excelsior*, December 2, 1991.

293. Details on the hatcheries are available in Revord and Weidner, "Ecuadorean Shrimp Culture," *op. cit.*, and Weidner and Revord, "Panamanian Shrimp Culture," *op. cit.*

294. Miller, *op. cit.* The authors do not know the basis for this estimate.

295. The price was quoted as 10 peso per pl, which converted to $3.26 per 1,000 pl (at the rate of 3,069 Mexican Pesos per U.S. Dollar prevailing in mid-April 1992). José Luis Gutierrez, *op. cit.* April 15, 1992.

296. The $2 reportedly goes to the respective cooperative and $1 goes to SEPESCA for the administration of shrimp culture related programs. Hicks, *op. cit.*, June 4, 1991.

297. Rosenberry, *Aquaculture Digest*, July 1987.

298. *El Nacional*, January 14, 1989.

299. Gutierrez, *op. cit.*, April 15, 1992.

300. Rosenberry, *World Shrimp Farming*, January/February 1992.

301. Lai, *op. cit.*

302. Gutierrez, *op. cit.*, April 15, 1992.

SECTION XV. (Feed)

303. One observer has identified 10 plants which produce marine and freshwater shrimp feeds. Together with 8 others, most of these plants also produce other aquatic feeds (catfish, tilapia, and trout). Benjamín Ruíz, Director of Animal Nutrition Market Development, American Soybean Association, Mexico City, personal communication, August 13, 1991.

304. SEPESCA, *El cultivo de camarón en México*, 1990.

305. Several observers noted that imported shrimp feed is subject to a tariff, which combined with the relatively small size of Mexico's shrimp feed market could explain why few foreign produced feeds are sold.

306. BIOTAC has reportedly built its own feed mill. NOVUM, which is looking to build an integrated hatchery and farm, is also reportedly considering building its own mill. Hicks, *op. cit.*, August 8, 1991 and Patricia Borrego, NOVUM, personal communication, August 9, 1991.

307. One observer estimates that so-called "specialty feeds" (for aquaculture, rabbits, horses, pets, etc.) represented less than 5 percent of Mexico's total feed production in 1989. Ruíz, personal communication, *op. cit.*

308. Samuel P. Meyers, "Study Links Chemoattractant with Better Feed Efficiency," *Aqua Trends*, Vol. 2, No. 2, Winter 1991. L. Elizabeth Cruz Suarez, Denis Ricque and Juan Pinal Mansilla, Universidad Autónoma de Nuevo Leon, "Nutritional value of different carbohydrate sources in *Panaeus vannamei* shrimp feed," *Program & Abstracts, op. cit.*; Marcelo Costero, Samuel Meyers and Luis de la Vega, "Evaluation of chemotactic perception and response to feed source by *Panaeus vannamei* under reproducible conditions," *Program & Abstracts, op. cit.*.; and Villarreal, *et. al.*, "Effect of substitution of shrimp meal for red crab meal in the growth of juvenile *Panaeus californiensis*," *op. cit.* The American Soybean Association has also sponsored soybean feeding trials as an ingredient in shrimp feeds. Benjamín Ruíz, *Aquaculture Soybean Feeding Trials: Trip Report*, June 10-14, 1991.

309. One of Mexico's major fishmeal producers, the Pesquera Zapata joint venture in Ensenada, recently closed.

310. Mexican growers may have difficulty obtaining quality feed at an acceptable price. One observer claims that feed costs, along with fuel expenses, have limited efforts to further intensify some operations. Garcia, Barra de Navidad Hatchery, *op. cit.* The authors have no information, however, to confirm this assertion. (See Section XII. Production Costs.)

311. Denis Ricque, L. Elizabeth Cruz Suarez, and Patricia Espinosa Gonzalez, "Nutritional evaluation of the baker's or brewer's yeast *Saccharomyces cerevisiae* as protein sources for *Panaeus vannamei* feed, *Program & Abstracts, op. cit.* Villarreal, *et. al.*, "Effect of substitution of shrimp meal, fish meal and soya meal for red crab meal," *Program & Abstracts, op. cit.*

312. L. Elizabeth Cruz Suarez, *et. al.*, "Evaluation of two shrimp byproducts meals as protein sources for *Panaeus vannamei* feed," *Program & Abstracts, op. cit.*

313. Ruíz, personal communication, *op. cit.*

314. Jaime Almazan de la Rosa, Alimentos Acuícolas el Pedregal, personal communication, September 20, 1991.

315. Jesus Zendejas, Purina S.A., Mexico City, personal communication, August 5, 1991.

316. George Chamberlin, Purina, personal communications, May 20, 1991.

317. Ruíz, personal communication, *op. cit.*

318. Cliff Reese, Director of Technology Transfer, Ziegler Feeds, personal communication, February 11, 1992.

SECTION XVI. (Processing)

319. "Se comprometen cooperativas a abatir rezagos en el sector pesquero," *Uno más Uno*, January 7, 1992.

320. Ecuador is developing what may become the largest shrimp processing capacity in Latin America. Mexico's total shrimp harvest peaked in 1987 at just over 87,000 t, and has declined dramatically. Ecuador's total harvests, which may have reached 100,000 t in 1991, have exceeded Mexico's since 1988 (appendix E3).

321. SEPESCA, *Anuario Estadistico de Pesca*, various issues.

322. Avelino Hernández Vélez, "La Industria Pesquera, en Grave Crisis: Pobre Infraestructura," *Financiero*, July 4, 1991.

323. The author indicates that many of these plants have obsolete facilities. "Creció 1.6% en 10 años la infraestructura camaronera," *Jornada*, July 16, 1991.

324. SEPESCA, *Anuario Estadistico*, various years.

325. The Salinas Administration is privatizing many state companies. One of the companies already privatized is Productos Pesqueros Mexicanos (PPM). Almost all of the company's packing plants have been sold. The Government also recently announced plans to privatize PPM's marketing subsidiary, Ocean Garden Products, during 1992.

326. Hernández, *op. cit.*

327. Such data is based largely on shrimp taken by fishermen, as growers have just begun to harvest and deliver important quantities of shrimp.

328. The Mexican Government announced in early 1992 that it plans to privatize OGP. Ignacio Herrera A., "A la venta, Ocean Garden Products; la convocatoria, lista en un mes," *Excelsior*, February 14, 1992.

329. Mexico's General Health Law gives the Secretaria de Salúd overall authority to regulate shrimp and other seafood.

330. Anonymous source.

331. Biologist Margarita Lizarraga Saucedo, Director, Instituto Nacional de Pesca, personal communication, September 26, 1991.

SECTION XVII. (Marketing)

332. The average price was reportedly above $23 (70,000 pesos) per kilo in early August 1991. Hicks, *op. cit.*, August 9, 1991.

333. Hicks, *op. cit.,* August 9, 1991.

334. For details, see Weidner, "Sinaloa Shrimp Culture," *op. cit.*

335. One recent press report, for example, suggests that half of Mexico's shrimp catch is consumed domestically. "Inauguró," *op. cit.*

336. The problem is further complicated by statistical anomalies in Mexican export and domestic consumption data. Under normal circumstances, the reported exports could simply be subtracted from total harvests, with the remaining amount assumed to have entered the domestic market. However, Mexico's export statistics do not agree with trade data from major importing countries. Nor does reported domestic consumption appear to account for the amount of product available in domestic markets. Part of the discrepancy can be explained by the different product forms when measured (with or without shells, heads, tails, etc.), but significant amounts of product also appear to be entering the market without being accounted for in official statistics.

337. "Por la competencia con otros países cae la venta de camarón mexicano a Estados Unidos," *El Nacional*, August 4, 1991.

338. Durwood Dugger, "Shrimp Farming in Mexico: Yesterday, Today and Tomorrow," *Aquaculture Magazine*, July/August 1990.

339. Mexico would face a major challenge in expanding shipments to Japan and Europe to compensate for a loss of the U.S. market. Gildardo Garcia, "Mas Ventas de Camarón a Europa y Japón, si EU Procede al Embargo," *Excelsior*, April 25, 1991.

340. See Paul Niemier and Mark Wildman, "Chinese Shrimp Culture," *International Fisheries Report* (IFR/91-43), June 14, 1991.

341. Ecuador in particular is shipping substantial quantities to Europe, mostly Spain and France. Revord and Weidner, "Ecuadorean Shrimp Culture," *op. cit.* Several other countries (Colombia, Guatemala and Panama) are also reporting success.

SECTION XVIII. (Outlook)

342. "Shrimp soars," *Seafood International*, January 1991.

343. Dugger, "Shrimp Aquaculture in Mexico," *op. cit.*

344. *Fish Farming International*, September 1991.

APPENDICES

Set A. -- Addresses
Set B. -- Glossary
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Set A.--Addresses

Appendix A1.--Mexico. Agencies and Research Facilities.

Arizona Fish and Game Department
Carretera a Guaymas Km. 2.5
Cx.P. 1497
Hermosillo 83000, Sonora

Centro de Estudios Tecnológicos del Mar
CET-MAR Alvarado
Km. 47, Carretera Veracruz-Alvarado
Alvarado 95259, Veracruz

Centro de Estudios Tecnológicos del Mar
CET-MAR Campeche
Km. 1, Carretera Campeche-Hampolol
Cd. del Carmen 24020, Campeche

Centro de Estudios Tecnológicos del Mar
CET-MAR La Paz
Terrenos del Conchalito
La Paz 23000, Baja California Sur

Centro de Estudios Tecnológicos del Mar
CET-MAR Mazatlán
Carretera Internacional Sur de Urias
Estero la Sirena
Cx.P. 655
Mazatlán 82000, Sinaloa

Centro de Estudios Tecnológicos del Mar
CET-MAR Salina Cruz
Prolongación Playa Abierta
Cx.P. 253
Salina Cruz 70600, Oaxaca

Centro de Estudios Tecnológicos del Mar
CET-MAR Teacapán
Domicilio Conocido
Teacapán, Sinaloa

Centro de Estudios Tecnológicos del Mar
CET-MAR Tuxpan
Domicilio conocido, Viveros
Tuxpan 82560, Veracruz

Centro de Investigación Cientifica y de Educación
Superior de Ensenada
Avenida Espinoza 843
Obrera Cx.P. 2732
Ensenada 22830, Baja California

Centro de Investigaciones Biologicas de Baja
California Sur
Carretera al norte, km. 17 "Comitan"
Cx.P. 128
La Paz 23000, Baja California Sur

Centro de Investigaciones y Estudios Avanzados
Unidad Mérida
Antigua carretera a Progreso km. 6
CORDEMEX
Cx.P. 73
Mérida 97310, Yucatán

Centro Ecológico de Sonora
Area de Ecología Acuática
Carretera a Guaymas, km. 2.5
Cx.P. 1497
Hermosillo 8300, Sonora

Fideicomiso Fondo Nacional para el Desarrollo Pesquero (FONDEPESCA)
Rio Elba No. 22
Col. Cuauhtemoc
México 06500, D.F.
Tel: 211-5772, 211-5218
FAX: 211-5858

Fondo para el Fomento de Acuacultura en el Estado de Sonora (FFAES)
Elias Callea 1005
Ciudad Obregón, Sonora

Instituto Nacional de Pesca
CRIP Puerto Morelos
Apartado Postal 580
Cancun 77500, Quintana Roo

Insitituto Nacional de Pesca
CRIP Yucatan
Apt. Postal 73
Progresso 97320, Yucatán

Instituto Politécnico Nacional
Centro Interdesciplinario de Ciencias Marinas
Playa a Conchalito
La Paz 23000, Baja California Sur

SEPESCA Delegación Baja California
Av. López Mateos No. 515-6
Ensenada 22800, Baja California
Tel: 401-40, 406-46, 400-75
FAX: 405-15

SEPESCA Delegación Baja California Sur
Esq. Jalisco y Madero
Col. Pueblo Nuevo
La Paz 23060, Baja California Sur
Tel: 244-14, 278-05

SEPESCA Delegación Campeche
Calle 12 No. 213
Campeche 24000, Campeche
Tel: 120-29, 117-96
FAX: 622-38

SEPESCA Delegación Cd. del Carmen
Héroes del 21 de Abril
Prolongación Playa Norte
Tel: 201-20, 223-23, 209-64

SEPESCA Delegación Chiapas
Tapachula Av. Circunvalación No. 112
Col. Moctezuma
Tuxtla Gutiérrez 29030, Chiapas
Tel: 293-48, 270-92
FAX: 293-46

SEPESCA Delegación Colima
Av. Juárez No. 244 2o. Piso
Edificio de la CROM
Manzanillo 28200, Colima
Tel: 201-27, 219-04, 221-02
FAX: 208-15

SEPESCA Delegación Guerrero
Costera Miguel Aléman 2o. Piso del Palacio Federal
Acapulco 39670, Guerrero
Tel: 350-89, 373-30, 351-89, 353-22
FAX: 250-62

SEPESCA Delegación Jalisco
Av. Niños Héroes No. 2036
Guadalajara 44100, Jalisco
Tel: 30-32-50, 16-84-92, 16-86-13
FAX: 15-63-14

SEPESCA Delegación Morelos
Av. Chapultapec No. 61er. Piso
Col Chapultapec
Cuernavaca 62480, Morelos
Tel: 15-88-12
FAX: 15-87-81

SEPESCA Delegación Nayarit
Av. Allende No. 110 Ote. Desp. 309
Tepic 63000, Nayarit
Tel: 209-27, 275-45, 269-68, 269-88
FAX: 250-61

SEPESCA Delegación Oaxaca
Calle Pacífico No. 13
Esq. Av. Manuel Avila Camacho
Barrio Cantarrana
Salina Cruz 70680, Oaxaca
Tel: 412-43, 412-44, 412-26
FAX: 400-82

SEPESCA Delegación Sinaloa
General Pesquira No. 502 Altos
Esq. Juan Carrasco
Mazatlán 82000, Sinaloa
Tel: 161-02, 230-10, 244-28, 226-02
FAX: 237-28

SEPESCA Delegación Sonora
Av. Aquíles Serdán No. 375 Altos Oriente
Guaymas 85400, Sonora
Tel: 253-41, 266-40, 260-71, 226-76
FAX: 238-02

SEPESCA Delegación Tabasco
Paseo de la Sierra No. 613
Villahermosa 86190, Tabasco
Tel: 352-90, 336-73
FAX: 337-15

SEPESCA Delegación Tamaulipas
López Rayón No. 308
Esq. con Avila Camacho
Col. Vergel
Tampico 89150, Tamaulipas
Tel: 338-73, 381-19, 381-71
FAX: 357-37

SEPESCA Delegación Veracruz
Campestre No. 1
Esq. Prolongación Díaz Mirón
Veracruz 91930, Veracruz
Tel: 37-13-09, 35-39-99, 35-36-78
FAX: 35-29-13

SEPESCA Delegación Yucatán
Calle 65 No. 627
Entre calles 76 y 78
Mérida 97000, Yucatán
Tel: 23-3100

Universidad Autónoma de Baja California Sur
Centro Interdisciplinario de Ciencias Marinas
Centro de Investigaciones Biológicas
Km. 5.5, Carretera al sur
Cx.P. 219
La Paz 23000, Baja California Sur

Universidad Autonoma de Guadalajara
Laboratorio de Ciencias Marinas
Av. Miguel Lopez de Legazpi 235
Barra de Navidad 48987, Jalisco

Universidad Autonoma de Tabasco
Av. Universidad, Zona de la Cultura
Cx.P. 298
Villahermosa 86000, Tabasco

Universidad Autonoma de Tamaulipas
Centro de Investigaciones Acuicolas y Pecuarias del Estado de Tamaulipas
Km. 5, Carretera Victoria-Mante
Cx.P. 263
Ciudad Victoria 87000, Tamaulipas

Universidad de San Diego
Km. 106, Carretera Tijuana-Ensenada
Cx.P. 453
Ensenada 22800, Baja California

Universidad de Sonora
Centro de Estudios Superiores
Talamantes s/n
Prol. Sur Carretera
Huatabampo, Unidad Deportiva
Cx.P. 455
Navojoa, Sonora

Universidad de Sonora
Centro de Investigaciones Cientificas y Tecnologicas
Rosales y Niños Heroes
El Centro
Hermosillo 83000, Sonora

Universidad Juarez Autonoma de Tabasco
Av. Universidad
Zona de la Cultura
Cx.P. 298
Villahermosa 86000, Tabasco

Appendix A2.--Mexico. Consultants and Promotional Groups.

Acuacultura Internacional
Apartado Postal 343
Mazatlán, Sinaloa
Fax: 698-3-67-11

Acuacultura Profesional
Rosales y Obregón
2° Piso 215 Edificio Clothier
Culiacán, Sinaloa

Acuícola Ejidal Ejidatarios Unidos de la Brecha
Ejido La Brecha
Guasave, Sinaloa

Alta Tecnología Acuícola de Colima (ALTACSA)
Canal de Ventana 10
Colima, Colima

Aquanova
7825 Fay Avenue Suite 200
La Jolla, CA 92037
Tel: (619) 456-5758
FAX: (619) 454-2679

Asociación Americana de Soya
Río Sena No. 26
Col. Cuáutemoc
Mexico 06500, D.F.

Camara Nacional de la Industria Pesquera
(CANAINPES)
Manuel María Contreas 133 desps. 401 al 405
México 06500, D.F.
Tel: 546-5234, 566-9411
FAX: 546-0828

CANAINPES -- Sección de Camarón, Langosta,
Abulon y Acuacultura
Manuel Ma. Contreras No. 133, 4 Piso
Colonia Cuauhtémoc
México 06500, D.F.
Tel: 566-9411, 546-5234
FAX: 564-6368

CANAINPES -- Delegación Campeche
Calle 10, No. 328 (A.P. 197)
Campeche 24599, Campeche
Tel: 628-64
FAX: 632-91

CANAINPES -- Delgación Cancún
Super Manzana 64 Manzana 15
Calle 15 Norte No. 45
Cancún, Quintana Roo
Tel: 438-39
FAX: 408-51

CANAINPES -- Delegación Cd. del Carmen
Calle 22 No. 125
Cd. del Carmen 24100, Campeche
Tel: 202-74
FAX: 216-12

CANAINPES -- Delegación Ensenada
Alvarado y Calle 4ta. No. 432 Desp. 13
Enseñada 22800, Baja California
Tel: 408-17
FAX: 832-97

CANAINPES -- Delegación Frontera
Esteban Samberino y Cuauhtémoc s/n
Frontera, Tabasco
Tel: 203-01
FAX: 200-44

CANAINPES -- Delegación Guaymas
Calle 22 y Serdán Edificio Luebbert
Desp. 2 Planta Alta
Guaymas, Sonora
Tel: 205-22, 215-35
FAX: 251-66

CANAINPES -- Delegación La Paz
Paseo Alvaro Obregón entre Allende y Juárez
La Pa, Baja California Sur
Tel: 234-40
FAX: 285-13

CANAINPES -- Delegación Mazatlán
Av. Alemán No. 912
Mazatlán 82000, Sinaloa
Tel: 136-35
FAX: 504-79

CANAINPES -- Delegación Progreso
Calle 30 x 21 No. 109
Progreso 97320, Yucatán
Tel: 505-93
FAX: 500-15

CANAINPES -- Delgación Salina Cruz
Calz. Teniente Azueta No. 16
Salina Cruz 70600, Oaxaca
Tel: 419-84
FAX: 403-84

CANAINPES -- Delegación Tampico
Av. Hidalgo No. 306 Sur
Tampico, Tamaulipas
Tel: 12-85-58
FAX: 12-49-03

CANAINPES -- Delegación Yacaros
A.P. 60
Huatabampo 85900, Sonora
Tel: 604-13, 608-00
FAX: 606-85

CANAINPES -- Representación Alvarado
Calle Matamoros No. 6
Alvarado 25250, Veracruz
Tel: 310-61

CANAINPES -- Representación Manzanillo
Hidalgo No. 266 ó Niños Héroes 517
Manzanillo 28200, Colima
Tel: 214-86, 206-64

CANAINPES -- Representación Puerto Peñasco
Constitución y Nicolás Bravo
Puerto Peñasco, Sonora
Tel: 325-89, 322-52
FAX: 324-11

CANAINPES -- Representación San Felipe
Calle Manzanillo No. 449
San Felipe 21850, Baja California
Tel: 710-52

CANAINPES -- Representación Tepic
Mina No. 76 Pte.
Tepic, Nayarit
Tel: 256-95
FAX: 272-40

CANAINPES -- Representación Tuxpan
Calle Garizurieta No. 4
Col. Ruiz Cortínez
Tuxpan, Veracruz
Tel: 415-836
FAX: 445-12

CANAINPES -- Subdelegación Puerto Madero
A.P. 684
Antigua Carretera Km. 2
Tapachula, Chiapas
Tel: 519-79, 552-12

Constructora Pigali
Av. Mochis 1352
Col. Guadalupe
Culiacán, Sinaloa

Contratistas en Camarón
El Aparecido
Guillermo Prieto 855 Nte.
Culiacán, Sinaloa

Deep Sea Shrimp Importing Company
101 South First Street Suite 401
Burbank, California 91502
Tel: (213) 849-6679, (818) 846-5222
FAX: (818) 846-0482

Desarollo y Construcciones Acuícolas
Sinaloaenaca
Guillermo Prieto 980 Sur Altos
Los Mochis, Sinaloa

Federación de Acuicultores de México
Patriotismo 246 Col. San Pedro de los Pinos
Mexico 03800, D.F.

Federación de Acuícultores de México
Río Sinaloa los Mochis
Los Mochis, Sinaloa

Federacion Mexicana de Acuacultores
Fco. I Madero #108 Ote., 2 piso, Desp. #3
Tampico, Tamaulipas

Fed. Reg. de Soc. Coop. del
Centro de Sinaloa
Blvd. Emiliano Zapata 1434
Culiacán, Sinaloa

Fed. Reg. de Soc. Coop. de la
Ciudad y Puerto de Mazatlán
Potrero del Llano y Constitución No. 140
Mazatlán, Sinaloa

Fed. Reg. de Soc. Coop. Ind. Pes. de
Alta Mar, Topolobambo
Bienestar 151 Ote.
Topolobambo, Sinaloa

Fed. Reg. de Soc. Coop. Norte de
Sinaloa y Sur de Sonora
Grenistar 103 Pte.
Los Mochis, Sinaloa

France Aquaculture
c/o SANOFI de Mexico
Calzada Mexico Xochimilco 4832
Mexico 14370, D.F.

Industrias Michel
Blvd. Emiliano Zapata Km. 2
Culiacán, Sinaloa

Linea Cooperativa
Marsella #11
Colonia Juarez 06600
Mexico, D.F.

NOVUM
Boques de Ciruelos No. 180
Bosques de las Lomas
Mexico 11700, D.F.

Ocean Garden Products
P.O. Box 81227
San Diego, CA 92138

Pesquera Zapata
P.O. Box 12D
San Isidro, CA 92073-02220

Promotora Independente Acuasistemas (PAISA)
Miraflores 322
La Paz, Baja California Sur

Revista Acuacultura Internacional
Apartado Postal 342
Mazatlán, Sinaloa

Sección de Cooperativistas Pesqueras de
la CANACOP
Marsella 11, Col. Juárez
México, D.F.

Unidad Cooperativas Acuícolas del
Municipio de Navolato
Calle Almada
Navolato, Sinaloa

Appendix A3.--Mexico. Farms.

Acuacultora Campechana
Apartado Postal 166
San Roman 24040, Campeche
MEXICO

Acuacultores de Dimas
Ahome, Sinaloa
Tel: 698-1-69-11, 2-54-47 (Mazatlán)
678-2-25-98

Acuacultores de la Península de Baja California
Apartado Postal 627
La Paz 23000, Baja California Sur
Fax: 682-5-62-20

Acuacultura en Avance
Paredones
Los Mochis, Sinaloa
Tel: 681-5-68-59

Acuacultura la Atarralla
Juan Carrasco No. 689 Nte.
Culiacán, Sinaloa

Acuanauplio
San Ignacio, Sinaloa

Acuatecnología de Pijijiapan
Calle 2 No. 34
Ciudad Pijijiapan, Chiapas
Tel: 964-5-03-98
Fax: 964-5-03-98

Acuavision
Navolato, Sinaloa
Tel: 672-4-37-30, 5-33-27

Acuicola 6 de Agosto de 1987
Las Glorias, Ejido Progreso Unido
Guasave, Sinaloa

Acuicultores Mar Land
Parque Sinaloa No. 452
Fracc. El Parque
Los Mochis, Sinaloa
Tel: 681-5-19-06

Ahome Acuicola
Blvd. Rosales 379 Sur
Despacho 203-205
Los Mochis, Sinaloa
Tel: 681-5-090
FAX: 681-5-0703

Aquacop
El Colorado
Los Mochis, Sinaloa

Asociación en Copropiedad del Siglo XXI
Poblado Bachoco II
Los Mochis, Sinaloa

Barra de la Tonina
Las Aguamitas
Navolato, Sinaloa

Boca del Río Quelite
Blvd. de las Américas 300 Nte.
Culiacán, Sinaloa

Boca del Río San Lorenzo S.C.L.
Dom. conocido El Robalar
Culiacán, Sinaloa

BIOTAC
Apartado Postal 813
Circuito el Campeador No. 2
Col. Fracc. El Cid
Mazatlán, Sinaloa

Camaronera de Ahome
Zaragoza y 10 de Mayo
Los Mochis, Sinaloa
Tel: 681-2-34-50
Fax: 2-26-13

Camaronera del Centro
Culiacán, Sinaloa
Tel: 671-5-32-32, 3-37-29

Camaronera Ribereña
Dautillos
Navolato, Sinaloa

Camaronicultores de Sinaloa
Apartado Postal 8330
Escuinapa, Sinaloa
Tel: 678-3-67-11
Fax: 4-33-36

Chapobampo
Km. 14 Carretera Huatabampito
Huatabampo, Sonora

Cultivos Morales
San Miguel, Nayarit

David Porter
Campo Pesquero Las Aguamitas
Navolato, Sinaloa

Ejiditarios Unidos de la Brecha
La Brecha, Sinaloa

El Aparecido
Bahía de Navachiste
Municipio Ahome, Sinaloa
Tel: 681-2-44-00, 2-84-00
Fax: 5-45-34

El Brinco
Rafael Buelna 430 Ote.
Culiacán, Sinaloa

El Camarón Blanco
Municipio Navolato, Sinaloa
Tel: 671-2-72-28, 2-13-56
681-2-34-50, 2-19-95 (Los Mochis)

El Tetuan
Rosales 859
Sinaloa

El Trozado
Belissario Domínguez 1843 Sur
Culiacán, Sinaloa
Tel: 681-5-16-18 (Los Mochis)

Estero de la Ventana
Mochis y Sinaloa Col. Guadalupe
Sinaloa
Tel: 3-92-69, 5-71-74, 3-90-81

Estero El Caimán
Calle Arquitéctos 269
Col. Burócratas
Culiacán, Sinaloa
Tel: 671-3-37-95

Estero de Ponce
Domicilio conocido El Dorado
Sinaloa
Desarrollo Acuicola "Mar y Sol,"
Navolato, Sinaloa
Tel: 672-3-55-97, 6-84-76, 2-25-82

General Leyva
Campo Pesquero Las Lajitas
Higuera de Zargoza
Los Mochis, Sinaloa

Industrias Acuicolas del Golfo (IAGSA)
Calle 3 No. 210D
Col. García Ginerés
Mérida, Yucatán
Tel: (99) 25-89-20
FAX: (99) 25-06-71

Isla del Padre
Río Tehuantepec 983 Pte.
Col. Morelos, Culiacán
Sinaloa
Tel: 671-4-24-80, 4-16-35
Fax: 4-25-58

Jumari
Calle Mercado 53
San Blas, Nayarit

La Anchoveta
Sindicatura de Chametla
Rosario, Sinaloa
321-3-12-55, 3-15-25

La Bacapora
El Cerro
Angostura, Sinaloa
Tel: 673-2-31-87

Laguna del Chonte
Ejido Angeles 2
Navolato, Sinaloa

La Nueva Alternativa
Ejido La Bandera
Navolato, Sinaloa

La Tarraya
Municipio Navolato, Sinaloa
Tel: 5-33-90

La Tempehuaya
Colonia Buenos Aires
Navolato, Sinaloa

Las Lomitas
Gabriel Leyva 101
Escuinapa, Sinaloa
Tel: 675-3-02-04, 3-00-86, 3-14-00

Las Piedritas
Blvd. Emiliano Zaopata 2071 Pte.
Culiacán, Sinaloa
Tel: 671-4-50-22, 2-08-30

Litorales de Rilalogamugue
Culiacán, Sinaloa
Tel: 67-6-48-18, 2-18-18
Fax: 6-02-07

Mapahui
Topolobampo, Sinaloa

Maricultivos de la Costa de Chiapas
Pijijiapan, Chiapas
Tel: 964-5-02-18

Martha F.
Serdán y Calle 12 No. 460 Pte.
Guaymas, Sonora

Matacahui
Ejido Higuera de Zaragoza
Los Mochis, Sinaloa

Melesio Torres
Las Grullas Margen Izquierda
Ahome, Sinaloa

Molino de Sal Casa Blanca
Cerrada Nicaragua 27
Mazatlán, Sinaloa

Nicolas Liparodi López
Topolobampo, Sinaloa

Nueva Alternativa
Ejido La Bandera, Sinaloa

Nueva Tecnología del Pacífico
Escuinapa, Sinaloa
Tel: 4-06-63

Nueve de Mayo
Ejido Mochis #2
Los Mochis, Sinaloa

Península de Lucinilla
Domocilio conocido Altata
Navolato, Sinaloa

Pescadores de Bahía de Ceuta
Domicilio conocido El Conchal
Sinaloa

Pescadores El Brinco
Rafael Buelna 4300 Ote.
Culiacán, Sinaloa

Puntilla de Santa Anita
Belisario Domínguez 1843
Culiacán, Sinaloa

Playa Negra
Ejido Playa Negra
Las Grullas Margen Izquierda
Ahome, Sinaloa

Poblado #5
Poblado Numero 5
Valle del Carrizo, Sinaloa

Productora de Especies Acuaticas
Guasave, Sinaloa
Tel: 687-4-30-31
Fax: 687-4-30-85

Productos Alimenticios Bachoco
Culiacán, Sinaloa
Tel: 671-4-41-01, 4-62-61, 6-19-78, 6-51-78
Fax: 671-4-40-13

Punta Ahome
Las Grullas Margen Derecha
Ahome, Sinaloa

Ramon Ahumada
Las Glorias
Guasave, Sinaloa
Tel: 687-2-45-12, 687-2-13-92
Fax: 2-25-46

Raul Balbuena
Calle 20 de Noviembre
Los Mochis, Sinloa

Revolución Siglo XXI
Municipio Navolato, Sinaloa
Tel: 4-35-22, 4-20-72

Revolución XXIII
Domicilio conocido Sataya
Navolato, Sinaloa

Río Evora
Playa Colorado
Angostura, Sinaloa

Ribereña Dautillos S.C.L.
Dautillos
Navolato, Sinaloa

San Vicente
Higuera de Zaragoza
Los Mochis, Sinaloa
Tel: 681-5-28-98

Silvano Gaxiola
Campo Rancho Viejo
Municipio Guasave, Sinaloa
Tel: 687-2-13-92, 687-2-45-13
Fax: 2-25-46

Sistemas Acuícolas Controlados
Belisario Domínguez 1008
Culiacán, Sinaloa

Técnica Acuacultural de
la Zona Centro de Sinaloa
Casa Blanca
Guasave, Sinaloa

Tecnoacuícola de Nayarit
Palma 3 Col. San Juan
Tepic, Nayarit

Sol de Fuego
Madero 661-s Pte.
Los Mochis, Sinaloa
Tel: 681-5-75-41

Técnico de Cultivo
Ejido Plutotarco Elias Calles
Sinaloa

Tecnicos Acuicolas el Tetuan
Municipio de Navolato, Sinaloa
Tel: 3-75-44

Tecnicos Acuicolas Sinaloenses
Costa Rica, Sinaloa
Tel: 8-06-39

Vanamey
Las Palmas 13
San Blas, Nayarit

Appendix A4.--Mexico. Feed Companies

Abastecedora de Forrajes, S.A.
Calle 26 No. 2715
Zona Industrial
Guadalajara 44940, Jalisco

Albamex
Antigua Carretera a Chapala 3561
Zona Industrial
Guadalajara 44940, Jalisco

Alimentos Acuicolas el Pedregal
Juan Gutemberg No. 112
Col. Cientificos
Toluca 50000, México

Alimentos Pecuarios del Sureste S.A.
Km. 355 Carretera Federal Córdoba - Fortín
Córdoba 99500, Veracruz

Anderson Clayton & Co., S.A.
Gobernador Curiel 3601
Zona Industrial
Guadalajara, Jalisco

Coralesa
Calle 12 No. 1870
Col. FFCC
Guadalajara, Jalisco

Forrajea El Barrio S.A. de C.V.
Calle Hidalgo 5114 Col. Barrio
Culiacán, Sinaloa

Forrajes Payan, S.A.
Colón 919 Ote.
Col. Las Vegas
Culiacán 80090, Sinaloa

Purina S.A. de C.V.
Sombrerete 4425
Zona Industrial
Guadlajara 44940, Jalisco

Ziegler Brothers, Inc.
P.O. Box 95
Gardners, PA 17324-0095

Set B.--Glossary

Appendix B1.--Mexico. Selected shrimp species.

Scientific	Species English†	Spanish†
Marine		
Paneaus sp.	Panaeids/Shrimp	Penidios/Camarón
aztecus	northern brown	cafe norteño/café
brasiliensis	redspotted	rosado con manchas/café/moreno
brevirostris	crystal	cristal
californiensis	yellowleg	patiamarillo/café/kaki
duorarum	northern pink	rosado norteño/rosado
occidentalis	western white	blanco del Pacifíco/blando
robustus	pink	rosado norteño
setiferus	northern white	blanco norteño/blanco
stylirostris	blue	azul
vannamei	whiteleg	patiblanco/blanco
Hymemopeneus robustus	NA	rojo
Pleoticus robustus	royal red	rojo real
Sicyonia sp.		
brevirostris	rock	de piedra/de roca
penicillata	NA	japones
Trachipenaeus sp.		
faoea	indio	fijador indio/zebra
kroyeri	NA	sintético
similis	yellow roughneck	fijador amarillo/botalón
Xiphopenaeus sp.	Seabobs	
kroyeri	Atlantic	siete barbas
riveti	Pacific	botalón/siete barbas
Freshwater		
Macrobrachim sp.	Freshwater prawn	Langostino
acanthurus	NA	prieto
americanum	NA	de agua dulce
carcinus	NA	camarón de río
tenellum	NA	charal

† FAO English and Spanish terms. Commonly used American and Mexican names appear after slash in English and Spanish columns.
NA - Not Available
Sources: FAO, Species Catalogue: Volume 1 - Shrimps and Prawns of the World, Rome, 1980; FAO, "Lista Preliminar de Especies Acuaticas Autoctonas Cultivadas o en Experimentación para su Cultivo en America Latina," Circular de Pesca (FIP/C846), December 1991; NMFS; and Ocean Garden Products, Comportamiento del mercado de camarón, August-September 1991.

Set C.--Environment

Appendix C1.--Mexico. Climatic conditions at selected Pacific-coast sites.

Site	Latitude	Annual precipitation	Temperature variation	Postlarval availability
	Degrees	Millimeters	Degrees Celsius	
Mexico				
El Sauzal, Baja California	32° North	< 250	25°	February and July
Ceuta, Sinaloa	24° North	600	17°	February to November
Salina Cruz, Oaxaca	16° North	500	5°	Year-round
Ecuador	0° North	> 2,000	< 4°	June to November

Source: Pedro G. Sáenz M. and Francisco Magallón B., Instituto Nacional de la Pesca, "Analisis de las posibilidades del cultivo del camarón en el pacifico mexicano," Documentos de Trabajo Volume 1, No. 7, September 1989.

Appendix C2.--Mexico. Average monthly sea surface temperatures at selected coastal locations, 1989-91.

Year Month	Pacific Coast North	 Central	 South	Gulf of Mexico North	 South	Caribbean North
			Degrees Celsius			
1989						
January	14	17-21	26	26	24	20
February	13	18-21	25	26	25	19
March	15	20-24	26	26	25	20
April	17	23-25	27	26	26	22
May	19	24-25	28	27	27	24
June	20	27-27	29	28	28	27
July	22	28-29	29	28	28	29
August	20	26-28	29	29	29	29
September	20	27-29	29	29	29	29
October	20	25-28	29	26	28	29
November	19	25-28	29	24	27	28
December	18	24-27	28	20	25	27
1990						
January	16	20-26	27	18	24	26
February	15	18-24	25	18	23	26
March	16	20-26	27	20	25	26
April	16	22-26	28	22	26	27
May	18	26-27	29	25	27	27
June	20	27-28	29	28	28	28
July	21	28-29	29	29	29	29
August	22	29-30	30	29	29	29
September	23	30-30	30	29	29	29
October	24	28-30	29	27	29	29
November	20	25-28	27	24	27	28
December	19	23-27	27	22	25	27
1991						
January	17	21-24	28	21	25	26
February	16	21-25	27	20	25	26
March	17	21-25	26	20	26	26
April	16	20-25	27	23	26	27
May	16	20-24	29	25	26	28
June	17	20-28	30	28	29	29
July	20	22-28	29	29	28	29
August	19	23-30	29	29	29	29
September	20	21-29	29	29	29	29
October	22	24-29	28	26	28	28
November	20	22-28	28	24	27	28
December	18	20-27	28	21	25	27

Geographic areas:
North Pacific includes the northern Gulf of California (coast of Baja California and northern Sonora)
Central Pacific includes the southern Gulf of California (coast of Baja California Sur, Sinaloa, Nayarit, Jalisco and Michoacan)
South Pacific includes the Gulf of Tehuantepec (coast of Guerrero, Oaxaca and Chiapas)
North Gulf of Mexico (coast of Tamaulipas and northern Veracruz)
South Gulf of Mexico (coast of Veracruz, Tabasco and Campeche)
Caribbean (coast Yucatan and Quintana Roo)

Note: Temperatures are approximations based on visual estimates from map graphics.

Source: NOAA, Climate Analysis Center, Monthly Sea Surface Temperature Maps (primarily using TOGA Analysis), various months.

Appendix C3.--Comparison of sea surface temperatures, 1989-91.

Year/ Month	Southern Sinaloa	Southern Ecuador
	Degrees celcius	
1989		
January	21	23
February	21	24
March	24	25
April	25	25
May	25	21
June	27	24
July	29	22
August	28	23
September	29	22
October	28	23
November	28	22
December	27	25
1990		
January	26	25
February	24	25
March	26	26
April	26	24
May	27	25
June	28	24
July	29	24
August	30	25
September	30	25
October	30	22
November	28	22
December	27	22
1991		
January	24	24
February	25	26
March	25	25
April	25	25
May	24	24
June	28	25
July	28	24
August	30	24
September	29	23
October	29	25
November	28	25
December	27	24

Note: Temperatures are approximations based on visual estimates from map graphics.

Source: NOAA, Climate Analysis Center, Monthly Sea Surface Temperature Maps (pimarily using TOGA analysis), various months.

Set D.--Area

Appendix D1.--Mexico. Estimates of potential surface area available for shrimp culture, by state.

State	Estimated Potential Area		
	Source A	Source B	Source C
	1,000 Hectares		
Pacific coast			
Baja California	1.0	25.0	25.0
Baja California Sur	3.0	30.0	30.0
Sonora	40.0	40.0	40.0
Sinaloa	100.0	180.0	256.0
Nayarit	92.0	60.0	60.0
Colima	3.0	3.0	3.0
Oaxaca	50.0	50.0	50.0
Chiapas	15.0	40.0	309.0
Subtotal	304.0	428.0	773.0
Atlantic coast			
Tamaulipas	5.0	15.0	15.0
Veracruz	15.0	15.0	15.0
Tabasco	1.5	2.0	2.0
Campeche	10.0	10.0	10.0
Subtotal	31.5	42.0	42.0
Other States	20.0	-	-
Total	355.5	470.0	815.0

Note: Some observers believe that limited areas in Yucatán and Quintana Roo may also have some acceptable sites. A 1991 study, for example, prepared by the Centro Investigación y de Estudios Avanzados de IPN concluded that there about 5,000 ha of ponds could be built in Yucatán.
Sources: (A) SEPESCA, 1987; (B) SEPESCA, Programa Nacional de Cultivo de Camaron, October, 1987; (C) Andres Roemer and Jorge Mercado, Evaluacion Juridica, Financiera y Economica de la Camaronicultura en México, Mexico, 1990.

Appendix D2.--Mexico. Marine shrimp culture pond area, harvests and yields, 1985-92.

Year	Pond Area		Harvests	Average Yield*
	Constructed	Active		
	1,000 Hectares		Metric Tons	Tons/Hectare
1985	NA	0.1	100	1.0
1986	NA	NA	200	NA
1987	2.1	NA	800	NA
1988	4.5E	2.1	2,400	1.1
1989	5.1	2.5	3,200	1.3
1990	8.3	4.1E	5,400	1.3E
1991	8.9	5.2E	6,700	1.3E
1992	NA	NA	9,000P	NA

* For active ponds only
E - Estimated
NA - Not Available
P - Projected
Note: The 1985-87 harvests are based on SEPESCA estimates of the Sinaloa harvests, assuming that these represented 80 percent of the national total.
Sources: José Luis Gutierrez, Banco Somex, personal communication, July 9, 1990 (1987-89 harvests); Edgardo Hicks, U.S. Embassy, Mexico City, personal communication, July 8, 1990 (1988 pond area); SEPESCA, personal communications, February 26 and March 12, 1991 (1987, 1989 and 1990 pond areas); Dennis Weidner, NMFS, "Shrimp Culture in Latin America, 1986-90," International Fisheries Report (IFR/88-40), May 13, 1988.

Set E.--Catches/Harvests

Appendix E1.--World. Total shrimp harvests, 1980-91.

Year	Harvest		Total	Proportion
	Capture	Culture	Harvest	Cultured
	1,000 Metric tons*			Percent
1980	NA	NA	NA	NA
1981	NA	NA	1,627	NA
1982	1,653	84	1,737	5
1983	1,684	143	1,827	8
1984	1,746	174	1,920	9
1985	1,925	213	2,138	10
1986	1,927	309	2,236	14
1987	1,821	551	2,372	23
1988	1,902	604	2,506	24
1989	1,869	611	2,480	25
1990	1,875	652	2,527	26
1991	NA	699	NA	NA

* Liveweight equivalent
NA - Not Available
Sources: FAO, Fisheries Statistics Yearbook, various issues (total harvests); Bob Rosenberry, World Shrimp Farming, various issues (culture harvests); Dennis Weidner, NMFS, "Latin American Shrimp Culture Industry, 1986-90," International Fisheries Report (IFR-88/40), March 13, 1988 (culture harvests).

Appendix E2.--World. Estimated cultured shrimp harvests, 1988-91.

Region/ Country	Year					Change
	1987	1988	1989	1990	1991	1987-91
	1,000 Metric tons*					Percent
Asia						
China	153	199	175	150	145	(5)
Indonesia	73	96	97	120	140	92
Thailand	24	56	94	100E	110E	358
India	22	25	25	30	35E	59
Vietnam	20	22	22	30E	30E	50
Philippines	36	45	48	54	30E**	(16)
Taiwan	115	44	32	30	30E	(74)
Other	23	25	29	35	38	65
Subtotal	466	513	522	549	558	20
Latin America						
Ecuador	69	70	64	70	100	45
Colombia	1	1	3	6	10	900
Mexico	4	6	5	8	9	125
Peru	2	2	4	5	6	200
Honduras	2	2	3	3	5	150
Other	5	8	8	10	9	80
Subtotal	83	89	87	102	139	67
Africa	1	1	1	NA	NA	-
Middle East	Negl	Negl	Negl	Negl	Negl	-
Europe	Negl	Negl	Negl	Negl	Negl	-
North America	1	1	1	1	2	100
Oceania***	NA	NA	NA	NA	NA	NA
World Total	551	604	611	652	699	27

* Liveweight equivalent
** As reported by Rosenberry, World Shrimp Farming op. cit. The authors have no other confirmation of this sharp decline.
*** Included in the Asian totals.
NA - Not Available
Sources: Mark Wildman and Todd Schneider, "Asian Shrimp Culture," International Fishery Reports, in press (Asian Data) and appendix B4 (Latin American data).

Appendix E3.--Latin America. Total shrimp harvests by country, 1980-91.

Country	Year											
	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	1,000 Metric tons*											
Ecuador	17.0	20.1	29.5	44.6	39.9	36.2	52.8	78.7	82.6	78.4	84.7	NA
Mexico	77.6	72.0	78.7	78.9	76.1	74.6	73.2	83.9	73.2	74.8	62.3	62.0E
Brazil	57.9	46.3	52.1	49.2	58.6	67.5	55.4	54.6	47.7	48.9	50.0	NA
Colombia	4.7	5.3	6.0	5.8	8.1	5.0	6.2	6.7	7.8	10.9	11.3	NA
Argentina	0.8	2.7	7.8	19.3	23.1	10.3	7.0	2.8	18.1	11.9	10.0	NA
Peru	0.8	0.6	1.6	9.7	4.3	5.1	5.1	8.9	7.9	8.9	9.9	NA
Panama	10.5	15.3	14.7	14.2	11.8	18.4	16.1	10.6	9.5	13.4	9.0	NA
Costa Rica	3.5	4.6	4.5	2.7	4.4	8.7	8.7	8.8	8.9	8.9	9.0	NA
Venezuela	8.1	5.1	4.7	5.5	5.2	6.0	6.6	6.1	5.6	8.6	8.1	NA
Chile	2.7	2.9	3.5	6.6	3.9	2.9	3.0	4.5	5.0	5.6	6.6	NA
Honduras	2.6	3.1	2.7	3.3	3.6	3.8	5.8	5.2	7.5	4.2	5.0	NA
Guyana	2.0	2.1	2.0	2.0	2.4	3.2	3.1	2.9	3.7	3.8	3.9	NA
El Salvador	0.8	3.2	3.2	2.4	6.8	2.9	3.4	2.9	3.2	3.6	3.6	NA
French Guiana	0.1	0.3	0.5	0.5	0.5	0.6	1.1	2.8	2.6	3.0	3.7	NA
Guatemala	2.2	2.8	2.5	1.6	2.3	1.9	1.3	1.1	1.6	2.2	2.6	NA
Cuba	5.8	4.5	5.2	4.5	4.2	4.8	4.6	5.0	4.4	4.0	2.4	NA
Nicaragua	4.1	3.5	2.7	1.5	1.6	1.7	1.0	1.1	1.4	1.3	1.0	NA
Suriname	0.8	1.0	0.7	0.7	0.8	0.6	0.7	1.1	0.7	0.7	0.8	NA
Trinidad/Tobago	0.5	0.4	0.7	0.7	0.4	0.4	0.4	0.4	0.4	0.4	0.4	NA
Belize	0.1	Negl.	Negl.	Negl.	Negl.	0.1	0.3	0.3	0.3	0.8	0.3	NA
Dominican Rep.	0.8	0.6	0.5	0.3	0.4	0.2	0.2	0.3	0.2	0.1	0.1	NA
Martinique	-	-	-	-	Negl.	Negl.	0.1	0.1	0.1	0.1	NA	NA
Guadeloupe	-	-	-	-	Negl.	Negl.	Negl.	Negl.	0.1	0.1	NA	NA
St. Vincent	-	-	-	-	-	-	-	-	-	-	0.1	NA
Uruguay	-	Negl.	-	-	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	Negl.	NA
Jamaica	-	-	-	-	-	Negl.	Negl.	Negl.	Negl.	Negl.	NA	NA
Bahamas	-	-	-	-	-	-	-	-	-	Negl.	Negl.	NA

* Liveweight equivalent
E - Estimate
NA - Not Available
Negl. - Negligible
Source: FAO, Fishery Statistics Yearbook, various issues.

Appendix E4.--Latin America. Cultured shrimp harvests, 1980-91.

Country	Year											
	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	1,000 Metric tons*											
Ecuador	9.2	12.1	21.5	35.7	33.6	30.2	43.6	69.2	70.1	64.2	70.0E	100.0E
Colombia	-	-	-	-	Negl	0.1	0.2	0.5	1.3	3.0	6.0	9.8
Mexico†	0.1	Negl	0.1	2.4	3.9	3.4	3.3	4.0	6.1	4.7	7.8	9.2
Honduras	NA	0.1	0.2	0.3	0.5	0.6	1.3	1.9	2.4	3.2	3.2	4.5
Peru	NA	NA	NA	0.6	1.0	1.1	1.2	2.0	2.3	4.0	5.0	5.5E
Panama	NA	NA	0.8	0.8	1.5	2.6	3.0	2.8	3.5	3.5	3.5E	2.7E
Brazil†	-	-	Negl	0.1E	0.2E	0.4E	0.5E	0.5E	0.8E	1.3E	1.7E	NA
Guatemala	-	-	Negl	0.1	0.3	0.5	0.6	0.8	0.8	0.8	1.8	2.4E
Others	Negl	0.1E	0.2E	0.2E	0.2E	0.4E	0.9E	0.6E	1.6E	2.1E	3.0E	3.3E
Total	9.4	12.6	22.8	40.2	41.4	39.3	54.6	82.7	88.9	86.8	102.0E	139.1E

* Liveweight equivalent
† Includes a substantial quantities of freshwater shrimp.
E - Estimated
NA - Not available
Negl. - Negligible
Sources: Various country sources.

Appendix E5.--Mexico. Total shrimp harvests (capture and culture), 1970-90.

Year	Harvest Marine	Harvest Freshwater	Total
	1,000 Metric tons*		
1970	69.1	0.2	69.3
1971	71.5	0.3	71.8
1972	74.9	0.4	75.3
1973	72.7	0.7	73.4
1974	74.1	0.7	74.8
1975	68.8	1.0	69.8
1976	47.2	Negl.	47.3
1977	46.8	Negl.	46.8
1978	67.3	Negl.	67.3
1979	73.9	Negl.	73.9
1980	77.5	0.1	77.6
1981	72.0	Negl.	72.0
1982	78.7	0.1	78.8
1983	76.9	2.3	79.2
1984	76.1	3.8	79.9
1985	74.6	3.3	77.9
1986	73.2	3.1	76.3
1987	83.9	3.2	87.1
1988	73.2	3.7	76.9
1989	74.8	1.5	76.3
1990	62.3	2.4	64.7

* Liveweight equivalent
E - Estimated
NA - Not Available
Negl. - Negligible
Sources: FAO data and NMFS estimates.

Appendix E6.--Mexico. Total shrimp harvests by region, 1970-90.

Year	Harvest by Region Atlantic	Pacific	Inland	Total
	1,000 Metric tons*			
1970	25.9	43.2	0.2	69.3
1971	28.2	43.3	0.3	71.8
1972	30.5	44.4	0.4	75.3
1973	26.7	46.0	0.7	73.4
1974	29.1	44.9	0.7	74.8
1975	24.6	44.2	1.0	69.8
1976	17.8	29.4	Negl.	47.3
1977	19.2	27.6	Negl.	46.8
1978	26.1	41.2	Negl.	67.3
1979	27.8	46.1	Negl.	73.9
1980	27.6	49.9	0.1	77.6
1981	30.3	41.7	Negl.	72.0
1982	23.5	55.2	0.1	78.8
1983	23.1	53.8	2.3	79.2
1984	25.2	51.0	3.8	79.9
1985	25.5	49.1	3.3	77.9
1986	24.3	48.9	3.1	76.3
1987	24.3	59.6	3.2	87.1
1988	22.7	50.6	3.7	76.9
1989	23.0	51.8	1.5	76.3
1990	23.0	39.3	2.4	64.7

* Liveweight equivalent
E - Estimate
NA - Not Available
Negl. - Negligible
Sources: FAO data and NMFS estimates.

Appendix E7.--Mexico. Marine shrimp harvest, wild-caught and cultured, 1980-91.

Year	Marine Harvest		Total	Proportion
	Capture	Culture	Harvest	cultured
	1,000 Metric tons*			Percent
1980	77.5	Negl.	77.5	-
1981	72.0	Negl.	72.0	-
1982	78.7	Negl.	78.7	-
1983	76.8	0.1	76.9	0.1
1984	76.0	0.1	76.1	0.1
1985	74.5	0.1	74.6	0.1
1986	73.0	0.2	73.2	0.3
1987	83.1	0.8	83.9	1.0
1988	70.8	2.4	73.2	3.3
1989	71.6	3.2	74.8	4.3
1990	56.9	5.4	62.3	8.7
1991	55.3E	6.7	62.0E	10.8

* Liveweight equivalent
E - Estimate
NA - Not Available
Negl. - Negligible
Source: FAO data (1980-90 total harvest); NMFS estimates (1980-91 capture); U.S. Embassy, Mexico City/Banco Somex/SEPESCA (culture).

Appendix E8.--Mexico. Cultured shrimp harvest, 1980-91.

Year	Harvest		Total
	Marine	Freshwater	
	1,000 Metric tons*		
1980	Negl.	0.1	0.1
1981	Negl.	Negl.	Negl.
1982	Negl.	0.1	0.1
1983	0.1	2.3	2.4
1984	0.1	3.8	3.9
1985	0.1	3.3	3.4
1986	0.2	3.1	3.3
1987	0.8	3.2	4.0
1988	2.4	3.7	6.1
1989	3.2	1.5	4.7
1990	5.4	2.4	7.8
1991	6.7	2.5	9.2

* Liveweight equivalent
E - Estimate
Negl. - Negligible
Sources: Various NMFS and country sources.

Appendix E9.--Mexico. Cultured shrimp harvests by state, 1986.

Coast/ State	Harvest Marine	Harvest Freshwater	Total
	Metric Tons		
Pacific Coast			
Baja California	1	-	-
Baja California Sur	2	-	-
Sonora	6	-	NA
Sinaloa	16	NA	NA
Nayarit	7	NA	NA
Jalisco	1	NA	NA
Colima	-	NA	NA
Michoacan	-	NA	NA
Guerrero	4	NA	NA
Oaxaca	3	NA	NA
Chiapas	2	NA	NA
Pacific subtotal	42	779	822
Gulf of Mexico/Caribbean Coast			
Tamaulipas	6	NA	NA
Veracruz	-	NA	NA
Tabasco	-	NA	NA
Campeche	1	NA	NA
Yucatan	-	-	-
Atlantic subtotal	7	2,297	2,297
Interior States			
Aguascalientes	-	-	-
Coahuila	-	-	-
Chihuahua	-	-	-
Durango	-	-	-
Guanajuato	-	-	-
Hidalgo	-	NA	NA
Mexico	-	NA	NA
Morelos	-	NA	NA
Nuevo Leon	-	-	-
Puebla	-	NA	NA
Queretaro	-	NA	NA
San Luis Potosi	-	NA	NA
Tlaxcala	-	-	-
Zacatecas	-	-	-
Interior subtotal	-	18	18
Total Mexico	49	3,094	3,137

NA - Not Available
Source: SEPESCA, Anuario Estadistico de Pesca 1986, April 1988.
Note: The data on marine cultured harvest does not correspond to other information received by the NMFS, and presented in appendices E4 and E8. The authors are unable to explain the descrepancy.

Appendix E10.--Mexico. Cultured shrimp harvests by state, 1987.

Coast State	Harvest Marine	Harvest Freshwater	Total Harvest
	Metric Tons		
Pacific Coast			
Baja California	8	-	8
Baja California Sur	-	-	-
Sonora	23	-	23
Sinaloa	243	13	256
Nayarit	12	36	48
Jalisco	-	111	111
Colima	-	44	44
Michoacan	-	12	12
Guerrero	-	139	139
Oaxaca	-	-	-
Chiapas	-	40	40
Pacific subtotal	286	395	681
Gulf of Mexico/Caribbean Coast			
Tamaulipas	-	742	742
Veracruz	-	953	953
Tabasco	-	1,026	1,026
Campeche	-	1	1
Yucatan	-	-	-
Atlantic subtotal	-	2,722	2,722
Interior States			
Aguascalientes	-	-	-
Coahuila	-	-	-
Chihuahua	-	-	-
Durango	-	-	-
Guanajuato	-	-	-
Hidalgo	-	-	-
Mexico	-	Negl.	Negl.
Morelos	-	17	17
Nuevo Leon	-	-	-
Puebla	-	9	9
Queretaro	-	52	52
San Luis Potosi	-	29	29
Tlaxcala	-	-	-
Zacatecas	-	-	-
Interior subtotal	-	107	107
Total Mexico	286	3,224	3,510

Negl. - Negligible
Source: SEPESCA, Anuario Estadistico de Pesca 1987, November 1988.
Note: The data on marine cultured harvest does not correspond to other information received by the NMFS, and presented in appendices E4 and E8. The authors are unable to explain the descrepancy.

Appendix E11.--Mexico. Cultured shrimp harvests by state, 1988.

Coast State	Harvest Marine	 Freshwater	Total Harvest
	Metric Tons		
Pacific Coast			
Baja California	-	-	-
Baja California Sur	-	-	-
Sonora	9	-	9
Sinaloa	503	9	512
Nayarit	29	9	38
Jalisco	-	95	95
Colima	-	31	31
Michoacan	-	32	32
Guerrero	-	237	237
Oaxaca	-	Negl.	Negl.
Chiapas	-	27	27
Pacific subtotal	541	440	981
Gulf of Mexico/Caribbean Coast			
Tamaulipas	10	791	801
Veracruz	-	1,198	1,198
Tabasco	-	1,152	1,152
Campeche	-	1	1
Yucatan	-	-	-
Atlantic subtotal	10	3,142	3,152
Interior States			
Aguascalientes	-	-	-
Coahuila	-	-	-
Chihuahua	-	-	-
Durango	-	-	-
Guanajuato	-	-	-
Hidalgo	-	1	1
Mexico	-	6	6
Morelos	-	13	13
Nuevo Leon	-	-	-
Puebla	-	7	7
Queretaro	-	51	51
San Luis Potosi	-	7	7
Tlaxcala	-	-	-
Zacatecas	-	-	-
Interior subtotal	-	85	85
Total Mexico	551	3,667	4,218

Negl. - Negligible
Source: SEPESCA, Anuario Estadistico de Pesca 1988, April 1990.
Note: The data on marine cultured harvest does not correspond to other information received by the NMFS, and presented in appendices E4 and E8. The authors are unable to explain the descrepancy.

Appendix E12.--Mexico. Cultured shrimp harvests by state, 1989.

Coast State	Harvest Marine	 Freshwater	Total Harvest
	Metric Tons		
Pacific Coast			
Baja California	-	-	-
Baja California Sur	2	-	2
Sonora	3	-	3
Sinaloa	2,806	14	2,820
Nayarit	24	13	37
Jalisco	-	146	146
Colima	-	97	97
Michoacan	-	15	15
Guerrero	-	355	355
Oaxaca	-	Negl.	Negl.
Chiapas	-	13	13
Pacific subtotal	2,835	653	3,488
Gulf of Mexico/Caribbean Coast			
Tamaulipas	4	452	456
Veracruz	-	1,066	1,066
Tabasco	-	915	915
Campeche	-	1	1
Yucatan	-	-	-
Atlantic subtotal	4	2,434	2,438
Interior States			
Aguascalientes	-	-	-
Coahuila	-	-	-
Chihuahua	-	-	-
Durango	-	-	-
Guanajuato	-	-	-
Hidalgo	-	3	3
Mexico	-	-	-
Morelos	-	-	-
Nuevo Leon	-	-	-
Puebla	-	7	7
Queretaro	-	22	22
San Luis Potosi	-	32	32
Tlaxcala	-	-	-
Zacatecas	-	-	-
Interior subtotal	-	64	64
Total Mexico	2,839	3,151	5,990

Negl. - Negligible
Source: SEPESCA, Anuario Estadistico de Pesca 1989, July 1991.
Note: This data does not correspond to other information received by the NMFS, and presented in appendices E4 and E8. The authors are unable to explain the descrepancy.

Appendix E13.--Mexico. Cultured shrimp harvests in Sinaloa, 1985-90.

Year	Harvest
	Metric Tons
1985	95
1986	140
1987	616
1988	889
1989	2,736
1990	4,500E
1991	5,600E
1992	8,000P

E - Estimated
P - Projected
Note: These figures are considerably higher than those reported by SEPESCA in appendices E9-E12 above. The authors cannot explain the substantial discrepancy.
Sources: Jose Luis Gutierrez, Banco Somex de Mexico, personal communications, August 9, 1990, and July 8, 1991, (1985-90 harvests); U.S. Embassy, Mexico City, personal communication, July 1988 (1985-87 harvests); NMFS estimates.

Set F.--Price data

Appendix F1.--Mexico. Average domestic shrimp prices in Mexico City, May 1988 and May 1989.

Type of Product	Wholesale 1988	Wholesale 1989	Retail 1988	Retail 1989
	US$/kilogram*		US$/kilogram*	
Marine				
Cooked	8.92	11.81	11.63	14.64
Raw	10.74	10.96	17.40	14.87
Freshwater	11.75	14.19	14.93	16.98

* U.S. dollar price obtained based on market exchange rates listed by the Banco de México for the end of May 1988 and 1989 of 2,298 and 2,449 pesos/dollar, respectively.
Source: SEPESCA, Dirección General de Programación e Informatica.

Appendix F2.--Mexico. Average domestic shrimp prices in Mexico City, January and May 1989.

Type of Product	Wholesale January	Wholesale May	Retail January	Retail May
	US$/kilogram*		US$/kilogram*	
Marine				
Cooked	11.85	11.81	11.96	14.64
Raw	12.45	10.96	18.92	14.87
Freshwater	13.74	14.19	16.60	16.98

* U.S. dollar price obtained based on market exchange rates listed by the Banco de México for the end of January and May 1989 of 2,329 and 2,449 pesos/dollar, respectively.
Source: SEPESCA, Dirección General de Programación e Informatica.

Appendix F3.--Mexico. Estimated farm costs, 1990.

Costs	Farm size*		
	Small	Medium	Large
	US$/hectare		
Land	556	556	556
Construction			
Extensive	1,389	1,145	1,019
Semi-Intensive	4,618	4,042	3,794
Operating			
Extensive	775	710	684
Semi-Intensive	2,182	1,996	1,906

* Pond areas: Small--50 ha, Medium--100 ha, and Large--200 hectares.
Source: Margaret Miller, "Shrimp Aquaculture in Mexico," Food Research Institute Studies, Vol. 22, No. 1, 1990.

Appendix F4.--United States. Average shrimp price by major suppliers, 1991.

Country	Imports		Average
	Quantity	Value	Price
	Metric tons	Millions US$	US$
Mexico	**16,648**	**182**	**10.93**
Thailand	45,481	433	9.51
Indonesia	11,548	106	9.16
Phillipines	6,427	58	9.02
Panama	5,926	47	7.97
Ecuador	48,834	362	7.42
Honduras	5,878	42	7.15
China	35,115	220	6.26
India	17,513	67	3.85

Source: U.S. Bureau of the Census.

Appendix F5.--United States. Shrimp prices (31-40 count), May 3, 1991

Type/country	Price	Primary source
	US$/kilogram	
Whites		
U.S. (Gulf)	11.80	Trawler
Mexico		
No. 1	11.35	Trawler
No. 2	10.91	Trawler
Ecuador	10.58	Pond
China No. 1	8.93	Pond
Panama	10.58	Mixed
Black Tigers		
China	8.60	Pond
Thailand	8.71	Pond

Source: NMFS, Fisheries Market News Report, New York, May 3, 1991.

Appendix F6.--Mexico. Shrimp prices, in New York, 1990-92.

Year/ Month	Price*
	US$/Kilogram
1990	
January	NA
February	NA
March	NA
April	10.86
May	NA
June	NA
July	NA
August	10.03
September	9.37
October	NA
November	10.36
December	10.58
1991	
January	10.58
February	10.36
March	NA
April	10.53
May	NA
June	NA
July	NA
August	9.87
September	9.48
October	NA
November	9.92
December	9.92
1992	
January	9.65
February	10.09
March	NA

* Average price for 31/35 and 36/40 shrimp, including $0.10 shipping to New York.
NA - Not Available
Source: Ocean Garden Products, Comportamiento del Mercado de Camarón, various issues.

Set G.--Farm lists/data

Appendix G1.--Mexico. Number and pond area of operational shrimp farms, 1990.

State	Extensive		Semi-intensive		Extensive	
	Farms	Area	Farms	Area	Farms	Area
	Number	Hectares	Number	Hectares	Number	Hectares
Baja California Sur	-	-	2	60	-	-
Chiapas	-	-	2	60	-	-
Nayarit	16	248	3	45	1	1
Sinaloa	24	1,536	71	6,103	3	94
Sonora	-	-	4	81	3	48
Tamaulipas	-	-	2	NA	1	10

NA - Not Available
Source: SEPESCA, various sources, 1990.

Appendix G2.--Mexico. Number of farms by state, 1987-90.

Region State	1987	1988	1989	1990
	Number			
Pacific Coast				
Baja California	1	1	NA	-
Baja Sur	2	2	NA	2
Sonora	6	10	NA	7
Sinaloa	16	69	NA	98
Nayarit	8	5	NA	20
Jalisco	1	1	NA	-
Colima	-	-	NA	-
Michoacan	-	-	NA	-
Guerrero	-	1	NA	-
Oaxaca	1	1	NA	-
Chiapas	2	15	NA	2
Pacific Coast	37	105	NA	129
Atlantic Coast				
Tamaulipas	6	4	NA	3
Veracruz	-	-	NA	-
Tabasco	-	-	NA	-
Campeche	2	2	NA	-
Yucatan	-	-	NA	-
Quintana Roo	-	-	NA	-
Atlantic Coast	8	6	NA	3
Total	45	111	NA	132

Note: The data presented here is not confirmed by some other sources. The U.S. Embassy reported that Mexico had 65 operational farms in 1988, 54 of which were in Sinaloa. SEPESCA may be referring here to authorized or proposed farms rather than to those actually in operation.

Sources: SEPESCA, Inventario Nacional de Unidades de Produccion Acuicola, 1990; SEPESCA, Anuario Estadistico de Pesca 1988, April 1990.

Appendix G3.--Mexico. Number of shrimp farms by ownership, 1989 and 1990.

Farm Ownership	Farms 1989	1990
	Number	
Cooperative	25	33
Ejido	45	62
Private	35	37
Total	105	132

Source: SEPESCA, various sources.

Appendix G4 --Mexico. Results for Sinaloa farms, August 1991 to February 1992.

Location# and Name of Farm	Pond Area	Postlarvae demand	Harvest†	Yield‡
	Hectares	Millions	Metric tons	Tons/Hectare
Ahome (Zona Norte)				
Acuacultores del Norte de Sinaloa	100	56	100	1.0
Ahome Acuícola	108	20	400	3.7
El Aparecido	110	19	300	2.7
El Trozado	97	50	125	1.3
Finca Camaronera de Ahome	125	NA	150	1.2
Poblado No. 5	56	10	40	0.7
Puntilla de Santa Anita	83	50	108	1.3
Siglo XXI	10	4	20	2.0
Subtotal	689	209	1,243	1.8
Angostura (Zona Central)				
Bacapora	46	50	138	3.0
Pioneros de la Camaronicultura	80	14	66	0.8
Veinticuatro de Mayo	100	NA	72	0.8
Subtotal	226	64	276	1.2
Culiacán (Zona Central)				
Acuacultores de la Cruz Blanca	110	NA	60	0.5
El Patague	200	NA	100	0.5
Estero de Ponce	200	NA	115	0.6
Litorales de Rilalogamugue	60	2	66	1.1
Revolución Siglo XXI	180	16	180	1.0
Voluntad Humana	48	8	48	1.0
Subtotal	798	26	569	0.7
Elota (Zona Central)				
La Tempehuaya	300	20	100	0.3
La Tempehuaya II Somex	30	NA	30	1.0
Subtotal	330	20	130	
Escuinapa (Zona Sur)				
Camaronicultores de Siete Arriba Somex	100	20	120	1.2
Camaronicultores de Sinaloa	178	80	250	1.4
Las Lomitas Somex	137	50	210	1.5
Nueva Tecnologia Somex	12	6	60	5.0
Sistemas Acuaticos Controlados Somex	16	20	80	5.0
Subtotal	443	176	720	1.6
Guasave (Zona Norte)				
Costa Azul	173	51	173	1.0
Ejiditarios Unidos de la Brecha	100	32	100	1.0
El Caracol	27	8	27	1.0
Marismas	111	30	111	1.0
Pescadores de la Pionia	108	32	108	1.0
Productores de Especies Acuáticas	55	17	72	1.3
Ramon Ahumada	187	24	243	1.3
Silvano Gaxiola	69	7	69	1.0
Técnica Acuatica Zona Centro de Sinaloa	90	26	90	1.0
Subtotal	920	227	993	1.1
Mazatlán (Zona Sur)				
Clementina Somex	45	18	60	1.3
Navolato (Zona Central)				
Acuavison Somex	89	50*	100	1.1
Barra de la Tonina	75	18	75	1.0
David Porter	111	24	111	1.0
El Laco	70	NA	43	0.6
Isla del Padre Somex	58	21	92	1.6
Laguna de Carrizo	70	NA	40	0.6

Laguna de Chonte	65	5	46	0.7
La Nueva Aternativa	100	10	100	1.0
La Orquete	50	16	70	1.4
La Tarraya	75	34	150	2.0
Las Piedritas	36	19	40	1.1
La Ventana Somex	135	20	162	1.2
Loma Linda	92	20*	150	1.6
Mar y Sol	300	20	100	0.3
Peninsula de Lucenilla	114	16	180	1.6
Pescadores del Tigre	116	NA	70	0.6
Punto de Autata	115	20	115	1.0
Ribereña de Dautillos	136	34	136	1.0
Técnico Acuícola Sinaloënses	40	3	20	0.5
Subtotal	1,847	330	1,800	1.0
Rosario (Zona Sur)				
Cruz Naranjero Somex	10	3	10	1.0
La Anchoveta	40	10	98	2.5
La Loma Barrigona	6	10	7	1.2
Pescadores del Yauco Somex	26	6	24	0.9
Subtotal	82	29	139	1.7
San Ignacio (Zona Sur)				
Acuacultores de Dimas Somex	36	18	80	2.2
Total	5,416	1,117	6,010	1.1

♯ Mexican states are divided into municipios. Nearly all of Sinaloa's shrimp farms are located in the 10 coastal municipios of Ahome, Angostura, Culiacán, Elota, Escuinapa, Guasave, Mazatlán, Navolato, Rosario and San Ignaico.
† Estimated harvests
‡ Average yields
* Hatchery postlarvae
NA - Not Available
Source: Jose Luis Gutierrez Venegas, Gerente de Financiamiento Pesquero, Banco Mexican Somex, personal communication, April 15, 1992.

Appendix G5 --Mexico. Results for Sinaloa farms, August 1991 to February 1992.

Zone/ municipio#	Pond Area	Postlarvae demand	Harvest†	Yield‡
	Hectares	Millions	Metric tons	Tons/Hectare
North Zone				
Ahome	689	209	1,243	1.8
Guasave	920	227	993	1.1
Subtotal	1,609	436	2,236	1.4
Central Zone				
Angostura	226	64	276	1.2
Culiacán	798	26	569	0.7
Elota	330	20	130	0.4
Navolato	1,847	330	1,800	1.0
Subtotal	3,201	440	2,775	0.9
South Zone				
Escuinapa	443	176	720	1.6
Mazatlán	45	18	60	1.3
Rosario	82	29	139	1.7
San Ignacio	36	18	80	2.2
Subtotal	606	241	999	1.6
Total	5,416	1,117	6,010	1.1

Mexican states are divided into municipios. Nearly all of Sinaloa's shrimp farms are located in the 10 coastal municipios of Ahome, Angostura, Culiacán, Elota, Escuinapa, Guasave, Mazatlán, Navolato, Rosario and San Ignaico.
† Estimated harvests
‡ Average yields
* Hatchery postlarvae
Source: Jose Luis Gutierrez Venegas, Gerente de Financiamiento Pesquero, Banco Mexican Somex, personal communication, April 15, 1992.

Appendix G6.--Mexico. Pond area and yields for selected Sinaloa farms, 1988.

Name of Farm	Type	Pond Area		Production Yield	
		Actual	Projected	Actual	Projected
		Hectares		Metric tons/hectare†	
Acuacultura Campechana	SI	21.4	180	0.5	0.5
Acuacultores del Norte	SI	268.0	290	0.5	0.5
Alberto Reyes Lopez	SI	46.5	50	0.2	Negl.
Biotecmar	I	1.1	40	5.0	20.0
Ejidal Estero de Ponce	E	240.0	240	0.1	0.2
Ejidal Totoltboqui	SI	66.0	100	0.4	0.5
Modelo Acuicola	E	32.0	72	0.1	0.2
El Paiague	E	320.0	320	0.2	0.2
El Taxte	E	65.0	100	0.1	0.2
Tecnica Acuicola	SI	92.4	170	0.5	0.5

† Yield per cycle
E - Extensive methods
I - Intensive methods
SI - Semi-intensive methods
Source: SEPESCA, Boletín de Acuacultura, February 1988.

Appendix G7.--Sinaloa. Selected shrimp farms, 1990.

Name	Location	Ownership	Type	Pond Area
				Hectares
Acuacultora Matacahui	Higueras de Zaragoza, Ahome	Ejido	SI	181
Acuacultores de la Cruz Blanca	Nicolas Bravo, Culiacán	Ejido	SI	192
Acuacultores de Norte de Sinaloa	Las Grullas, Ahome	Private	SI	234
Acuacultores Fanuel	Boscoso, Elota	Ejido	SI	191
Acuavision	Bahía Santa María, Navolato	Private	SI	110
Barra de la Tonina	Marisma del Estero, Navolato	Cooperative	SI	101
Camaricultores de Sinaloa	San Jose de Platanar, Escuinapa	Private	SI	186
Costa Azul	Marisma el Perihuete, Guasave	Private	SI	205
Dautillos	Marisma de Dautillos, Navolato	Private	SI	141
David Porter	Marisma del Estero, Navolato	Cooperative	SI	115
Des. Acuícola Mar y Sol	Estero la Virgen, Navolato	Cooperative	SI	185
Ejidatarios Unidos de la Brecha	San José de la Brecha, Guasave	Ejido	SI	115
El Patague	Lucenilla y Robalar, Culiacán	Ejido	SI	360
El Trozado y Pta. de Santa	El Colorado	Cooperative	SI	161
Estero de Ponce	Estero de Ponce, Culiacán	Ejido	E	220
Estero la Ventana	Las Aguamitas, Navolato	Cooperative	SI	135
Finca Camaronera de Ahome	Bahía de Ohuira	Cooperative	SI	125
Jumalite	Laguna El Caimanero, Rosario	Cooperative	SI	120
Las Lomitas	Las Lomitas, Escuinapa	Private	SI	111
La Tempehuaya	Buenos Aires, Elota	Ejido	E	180
Matacahui	Higuera de Zaragoza	Cooperative	E	240
Nicolas Liparodi Lopez	Estero La Herradura	Ejido	E	204
Peninsula de Lucenilla	Los Algodones, Navolato	Cooperative	SI	137
Pescadores de la Pionia	Río Sinaloa, Guasave	Ejido	SI	110
Playa Negra	Estero la Niña, Ahome	Ejido	E	170
Ramon Ahumada	Las Glorias, Guasave	Private	SI	270
Sol de Fuego	Bahía Navachiste, San Ignacio	Cooperative	SI	150
Tec. Acuacultural Z.C. Sinaloa	Río Sinaloa, Guasave	Private	SI	217
Union de Pescadores de Altata	Los Algodones, Navolato	Private	SI	120
Veinticuatro de Mayo	Horcones, Angostura	Ejido	SI	147
Veinticuatro de Mayo	Playa Colorada, Angostura	Ejido	SI	110
Others (less than 100 hectares each)				783

E - Estimate
I - Intensive
SI - Semi-intensive
Source: Ignacio Galnares, SEPESCA, personal communication, March 1991.

Appendix G8.--Baja California Sur. Farms in operation, 1990.

Name	Location	Type	Ownership	Pond Area Hectares
Acuacultores de la Peninsula	Bahía Pichilinge	SI	Cooperative	30
Ley Federal de Aguas No. 6	NA	SI	Ejido	30

E - Estimate
I - Intensive
SI - Semi-intensive
NA - Not Available
Source: Ignacio Galnares, SEPESCA, March 1991.

Appendix G9.--Chiapas. Farms in operation, 1990.

Name	Location	Type	Ownership	Pond Area Hectares
Acuatecnologia de Pijijiapan	Palo Blanco	SI	Ejido	30
Maricultores de la Costa	NA	SI	Ejido	30

E - Estimate
I - Intensive
SI - Semi-intensive
NA - Not Available
Source: Ignacio Galnares, SEPESCA, March 1991.

Appendix G10.--Sonora. Farms in operation, 1990.

Name	Location	Type	Ownership	Pond Area Hectares
Acuacultivos del Pacifico	El Rancho	I	Cooperative	30
Acuícola Martha F.	El Cochorit	I	Cooperative	3
Chapobampo	Huatabampito	SI	Private	11
Cnolog. Acuícola Mar de Cortez	Tastiota	SI	Private	20
Grupo Genesis	Puerto Peñasco	I	Cooperative	15
Grupo Natantia	Bahía Kino	SI	Private	20
Tte. Juan de la Barrera	Ejido Tte. Juan de la Barrera	SI	Ejido	30

E - Estimate
I - Intensive
SI - Semi-intensive
Source: Ignacio Galnares, SEPESCA, March 1991.

Appendix G11.--Tamaulipas. Farms in operation, 1990.

Name	Location	Type	Ownership	Pond Area
				Hectares
El Moron	El Moron	SI	Ejido	NA
El Redondel	La Pesca	I	Private	10
Vista Hermosa	Ejido Vista Hermosa	SI	Ejido	36

E - Estimate
I - Intensive
SI - Semi-intensive
Source: Ignacio Galnares, SEPESCA, March 1991.

Set H.--Feed

Appendix H1.--Mexico. Fish meal supply, 1978-88.

Year	Domestic Production	Imports	Total
	Metric tons		
1978	38	25	63
1979	45	55	100
1980	88	60	148
1981	85	65	150
1982	115	31	146
1983	67	8	75
1984	60	25	85
1985	130	30	160
1986	110	20	130
1987	116	4	120
1988	108	22	130

Source: Sección de Fabricantes de Alimentos Balanceados para Animales, La Industria Alimenticia Animal en México, 1988-1989.

Appendix H2.--Mexico. Fish meal supply, 1981-88.

Year	Domestic Production	Imports
Metric tons		
1981	NA	23.8
1982	NA	30.7
1983	NA	NA
1984	NA	20.0
1985	NA	4.3
1986	84.0	5.4
1987	88.2	2.7
1988	81.9	26.1

NA -- Not Available
Note: Descrepancies between Government statistics and the numbers provided in Appendix H1 are unexplained.
Source: SEPESCA, Anuario Estadistico de Pesca, various issues.

Appendix H3.--Mexico. Price of fish meal†, 1985-89.

Year Month	Price	
	Pesos	U.S.$*
1985		
January	111,000	555
July	115,000	371
1986		
January	151,000	339
July	230,000	440
1987		
January	380,000	399
July	560,000	405
1988		
January	860,000	385
July	1,400,000	609
1989		
January	1,480,000	639
July	1,350,000	506

† National industry average of 63.65 percent protein content.
* U.S. Dollar price obtained from Mexican Pesos at average market exchange rates listed each month by the Banco de México.
Source: La Industria Alimentica Animal en México 1988/1989, Sección de Fabricantes de Alimentos Balanceados para Animales, 1990.

Set I.--Postlavae

Appendix I1.--Mexico. Hatcheries.

Coast/ state	Name	Location	Species	Monthly Capacity	Operational 1991
				Million pl	
Pacific					
Baja California Sur					
	Acuatores de la Peninsula	La Paz	P. vannamei	10	Yes
	Centro de Estudios Tecnológicos del Mar	La Paz	NA	NA	NA
Colima					
	Tecuanillo	NA	P. vannamei	3	NA
Guerrero					
	Universidad de Acapulco	NA	Freshwater	NA	NA
Jalisco					
	Univ. Autonoma de Guadalajara	Barra de Navidad	P. vannamei	1	Yes
Nayarit					
	San Blas	NA	P. vannamei	1	NA
Sinaloa					
	Acuacultivos del Pacífico	NA	NA	NA	No
	BIOTAC, S.A.	Escuinapa	P. vannamei	10	Yes
	Camaricultores de Sinaloa	Mazatlán	P. vannamei P. stylirostris	NA	NA
	El Tambor	Culiacán	P. vannamei	19	No
Sonora					
	Acuacultivos del Pacifico	Guayamas	P. vannamei	2	NA
	BIOTECMAR	NA	NA	NA	NA
	CICTUS	Puerto Peñasco	P. styloristris	NA	No
	Universidad de Sonora	Guayamas	Marine	NA	No
Atlantic					
Campeche					
	Acuacultora Campechana	NA	P. vannamei	3	NA
Quintana Roo					
	SEPESCA Lab	Puerto Morelos	P. brasilensis P. dourom	NA	No
Tabasco					
	Puerto Ceiba	NA	NA	NA	NA
Tamaulipas					
	Vincente Guerrero	NA	Marine†	1	No
	Toncal	NA	NA	Negl.	No
	El Morillo	Puerto Pesca	NA	Negl.	No
Veracruz					
	SEPESCA Lab	Tampico	NA	NA	No

† May include freshwater shrimp.
NA - Not Available
Sources: Edgardo Hicks, personal communications, May 31, 1991, and June 4, 1991; Hector M. Cappello, "The Autonomous University of Tamaulipas' Response to the State Fishery Sea Development," November 30, 1984 (Tamaulipas).

Appendix I2.--Mexico. Projected postlarvae supply, 1991.

Source	Annual Quantity
	Billion pl
Wild collection	1.5
Hatchery production	0.6
Imports*	-
Total	2.1

* Not generally allowed under current SEPESCA regulations.
Sources: Edgardo Hicks, U.S. Embassy, personal communication, June 11, 1991; and NMFS estimates.

Appendix I3.--Mexico. Shrimp postlarval production.

Coast/ State	Production 1985	1986	1987	1988
	Million pl			
Pacific				
Sinaloa	15	20	12	350
Nayarit	-	-	1	29
Sonora	20	27	10	25
Chiapas	2	-	Negl.	15
Baja California	-	-	-	4
Baja California Sur	Negl.	-	Negl.	2
Jalisco	-	-	-	1
Oaxaca	-	-	Negl.	-
Subtotal	37	47	24	426
Gulf of Mexico/Caribbean				
Tamaulipas	-	-	1	6
Campeche	Negl.	Negl.	Negl.	2
Subtotal	Negl.	Negl.	1	8
Total	37	47	25	434

* Both wild collection and hatchery output.
Source: SEPESCA, Anuario Estadistico de Pesca, various issues.

Appendix I4.--Mexico. Postlarval demand*, 2.0 harvests per year.

Area	Stocking Densities $5pl/m^2$	$10pl/m^2$	$15pl/m^2$	$20pl/m^2$
Hectares	Billion pl			
500	0.07	0.13	0.20	0.26
1,000	0.13	0.26	0.39	0.52
1,500	0.20	0.39	0.59	0.78
2,000	0.26	0.52	0.78	1.04
2,500	0.33	0.65	0.98	1.30
3,000	0.39	0.78	1.18	1.56
3,500	0.45	0.91	1.38	1.82
4,000	0.52	1.04	1.56	2.08
4,500	0.59	1.17	1.37	2.34
5,000	0.65	1.30	1.96	2.60

* Calculations adjusted to account for a 30 percent mortality rate.
Source: NMFS estimates.

Set J.--Processing

Appendix J1.--Mexico. Freezing plants, 1984-88.

Year	Plants: Nominal	Plants: Operating
	Number	Percent
1984	305	83
1985	314	71
1986	279	80
1987	253	82
1988	262	85

Source: SEPESCA, Anuario Estadistico de Pesca, various years.

Appendix J2.--Processing plants, 1984-91.

Year	Plants: Nominal	Plants: Operating
	Number	Percent
1984	479	81
1985	485	75
1986	444	80
1987	407	82
1988	406	84
1989	NA	NA
1990	NA	NA
1991	411	81

NA -- Not available
Sources: SEPESCA Anuario Estadistico de Pesca, various years (1984-88 data); and "Creció 1.6% en 10 años la infraestructura camaronera," Jornada, July 16, 1991 (1991 data).

Set K.--Trade data

Appendix K1.--World. Shrimp imports by the European Community, Japan, and the United States, 1982-91.

Country	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	1,000 Metric Tons											
Japan	143	162	151	149	169	183	213	246	261	264	284	285E
United States	99	101	124	155	155	163	181	217	229	228	227	245
European Community*	NA	NA	NA	NA	NA	NA	112	123	155	172	188	NA

* European Community imports refer only to Extra-EC imports, not Intra-EC imports.
E - Estimate
NA - Not Available
Sources: Japan Marine Products Importers Association, Japan Tariff Association, and LMR Shrimp Market Report (Japan data); U.S. Census Bureau (U.S. data); and EC NIMEXE (European Community data).

Appendix K2.--Mexico. Shrimp exports to the European Community, Japan, and the United States, 1980-91.

Country	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	Metric Tons											
United States	34.5	32.1	36.4	38.4	37.1	30.6	33.8	39.1	28.8	27.4	16.8	16.6
Japan	3.4	3.1	3.9	3.1	2.2	2.0	1.8	1.7	1.7	1.5	1.3	0.1
European Community	0.1	Negl.	-	-	-	-	-	-	-	-	-	-
Total	38.0	35.2	40.3	41.5	39.3	32.6	35.6	40.8	30.5	28.9	18.1	16.7

Sources: EC NIMEXE, Japan Tariff Association, and Bureau of the Census.

Appendix K3.--Mexico. Market for marine shrimp, 1980-90.

Year	Catch	Market	
		Domestic*	Export
1980	77.5	NA	38.0
1981	72.0	15.9	35.2
1982	78.7	19.6	40.3
1983	78.9	NA	41.5
1984	76.1	18.8	39.3
1985	74.6	22.0	32.6
1986	73.2	16.6	35.6
1987	83.9	24.4	40.8
1988	73.2	24.8	30.5
1989	74.8	NA	28.9
1990	62.3	NA	18.1
1991	62.0E	NA	16.7

* Apparent consumption as compiled by SEPESCA.
Note: The catch and domestic market data may not fully reflect the substantial quantities caught and marketed illegally.
Sources: FAO data; SEPESCA, Anuario Estadistico de Pesca, various issues.

Appendix K4.--United States. Shimp imports from Mexico, by size count, 1990.

Product/ Size	Imports	
	Quantity	Value
	Metric tons	US$ Million
Frozen Shell-on		
under 15	1,535	16.5
15/20	1,714	18.9
21/25	1,195	12.4
26/30	934	9.5
31/40	1,405	13.6
41/50	870	8.3
51/60	250	2.3
61/70	77	0.8
over 70	218	2.1
Unclassified†	5,071	52.6
Peeled	3,528	40.0
Canned	500	Negl.
Total	17,298	177.0

† Recording shrimp imports by size was introduced in July 1990. Product which entered the U.S. prior to July was not classified by size.
Note: Other data includes only fresh and frozen shrimp.
Source: U.S. Bureau of the Census.

Appendix K5.--United States. Shimp imports from Mexico, by size count, 1991.

Product/ Size	Imports Quantity	Imports Value
	Metric tons	US$ Million
Frozen Shell-on		
under 15	2,402	28.0
15/20	2,792	31.8
21/25	1,756	18.4
26/30	1,427	14.5
31/40	2,443	23.6
41/50	1,220	11.4
51/60	506	4.7
61/70	176	1.7
over 70	423	4.1
Peeled Frozen	3,489	43.4
Fresh	16	0.1
Prepared	24	0.1
Total	16,674	181.8

Source: U.S. Bureau of the Census.

Appendix K6.--United States. Shrimp imports from Mexico, 1980-91.

Year	Exports Quantity	Exports Value
	1,000 Metric tons	US $ Millions
1980	34.5	317
1981	32.1	290
1982	36.4	375
1983	38.4	388
1984	37.1	373
1985	30.6	297
1986	33.8	331
1987	39.1	401
1988	28.8	311
1989	27.4	285
1990	16.8	177
1991	16.6	182

Source: U.S. Bureau of the Census.

Appendix K7.--United States. Shrimp imports, by quantity, 1980-91.

Country	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	1,000 Metric tons											
Ecuador	9.2	11.2	16.4	23.3	21.1	19.9	28.1	45.9	47.2	36.8	38.3	48.8
Thailand	4.0	2.9	3.5	8.8	8.3	11.1	10.9	10.9	10.8	22.0	25.4	45.5
China	0.4	2.3	1.3	0.9	1.5	3.1	9.4	19.2	47.4	46.7	57.4	35.1
India	5.9	8.6	12.2	13.7	10.5	10.9	11.1	12.9	14.6	13.0	14.2	17.5
Mexico	**34.5**	**32.2**	**36.4**	**38.4**	**37.1**	**30.6**	**33.7**	**39.0**	**28.8**	**27.4**	**16.8**	**16.6**

Sources: NMFS, Fisheries of the United States, various years.

Appendix K8.--United States. Shrimp imports, by value, 1980-91.

Country	Year											
	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	Millions of U.S. Dollars											
Thailand	17	14	17	48	51	60	60	64	91	187	250	432
Mexico	317	290	375	388	373	297	331	401	311	285	177	182
Ecuador	68	80	137	219	186	166	278	379	382	308	291	362
China	4	18	12	6	13	21	63	119	300	277	355	220

Source: NMFS, Fisheries of the United States, various years.

Appendix K9.--United States. Shrimp imports, 1939-91.

Year	U.S. Imports Mexico	U.S. Imports Total	Mexican Portion
	1,000 Metric tons		Percent
1939	NA	1.8	NA
1940	2.2	NA	NA
1941	NA	NA	NA
1942	NA	NA	NA
1943	NA	NA	NA
1944	NA	NA	NA
1945	NA	NA	NA
1946	NA	NA	NA
1947	NA	NA	NA
1948	NA	9.8	NA
1949	NA	13.4	NA
1950	18.0	18.2	99
1951	17.2E	19.0	91E
1952	14.9E	17.5	86E
1953	15.4E	19.6	79E
1954	14.9E	NA	NA
1955	20.4E	NA	NA
1956	24.5E	NA	NA
1957	21.7	NA	NA
1958	25.4	NA	NA
1959	31.1	NA	NA
1960	33.4	NA	NA
1961	35.9	NA	NA
1962	35.2	NA	NA
1963	34.7	NA	NA
1964	32.7	NA	NA
1965	27.2	NA	NA
1966	31.1	NA	NA
1967	32.0	NA	NA
1968	27.2	NA	NA
1969	25.5	NA	NA
1970	32.6	NA	NA
1971	NA	NA	NA
1972	NA	NA	NA
1973	NA	NA	NA
1974	NA	NA	NA
1975	34.0	91.4	37
1976	36.5	104.2	35
1977	34.6	103.4	33
1978	32.9	89.9	37
1979	32.6	101.8	32
1980	34.5	99.5	35
1981	32.2	101.0	32
1982	36.4	124.2	29
1983	38.3	154.9	25
1984	37.1	155.3	24
1985	30.6	163.2	19
1986	33.8	181.4	19
1987	39.0	216.9	18
1988	28.8	228.5	13
1989	27.4	228.1	12
1990	16.8	227.4	7
1991	16.6	244.8	7

E - Estimate
NA - Not Available
Sources: BCF, Fisheries Flyers, 1950-1961; and NMFS, Fisheries of the United States, 1962-91.

3.7

NICARAGUA

Nicaragua has not yet developed a significant shrimp culture industry. Instituto Nicaraguense de la Pesca officials are convinced, however, that the country has the potential to be an important center for farmed shrimp. Government officials report a substantial area of suitable sites. Wild postlarval seedstock is readily available in estuaries along the northern Pacific coast. Climate and other physical factors appear favorable. The former Sandinista Government trained some specialists, and growers may also be able to draw on the methods and experienced personnel increasingly available in neighboring Central American countries. The new democratically elected Government is taking a much more favorable approach to the private sector after a decade of chaotic Sandinista statist economics. The Government is currently privatizing the moribund state fishing industry and most companies are scheduled to be in private hands by 1992. Promotional efforts by the Government appear to be stimulating significant interest on the part of investors who are planning numerous shrimp culture projects. Nicaragua's significant economic problems, however, have impaired the shrimp culture industry's development and continue to concern potential investors. Many observers report that the industry's most critical problem is financing. Some observers are convinced that Nicaraguan growers may achieve considerable success during the 1990s, despite the current unsettled economic and political situation. Even the most optimistic projections, suggest that harvests will probably not reach 5,000 metric tons by the year 2000 and more conservative projections of 2,000-3,000 tons appear more likely. Nicaragua's full potential, however, is substantial and Government officials are convinced that the country will eventually become the leading producer in Central America.

CONTENTS

I. CAPTURE FISHERY

Nicaragua has important shrimp resources along both its Caribbean and Pacific coasts.

Caribbean fishery: Nicaragua has a 460 kilometer (km) Caribbean coast. The Caribbean coast is blessed with an extensive network of estuaries that provide ideal nursery habitat for juvenile shrimp. Excellent fishing grounds with trawlable bottom conditions are found all along the coast from the

Map 1.--Map of Nicaragua.

mainland beaches out to beyond the many offshore cays and islands. As a result, most of the Nicaraguan catch has traditionally been taken in the Caribbean fishery (figure 1). The only significant shrimp port is Bluefields (map).

Pacific fishery: Nicaragua has a Pacific coast of about 305 kilometers. Shrimp are found along the entire coast, from the Gulf of Fonseca south to San Juan del Sur. Rocky bottom, however, limit trawling in many areas and fishermen have to fish further from the shore than they would like, generally beyond 20 meters (m) along much of the coast. This has a significant adverse impact on the fishery because some of the larger white shrimp populations are believed to be in waters of 30 meters or less. As a result, catches along the Pacific are usually only a fraction of Caribbean catches. The principal ports are Corinto, Puerto Sandino, and San Juan del Sur (map).

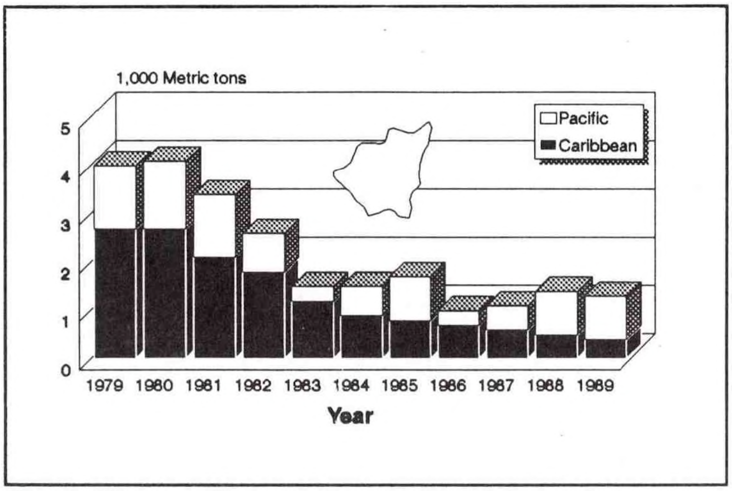

***Figure 1**.--Nicaragua. Fisherman have reported sharply lower shrimp catches, especially off the Caribbean coast where most of the catch used to be taken.*

Nicaraguan only began significant shrimping operations in the early 1960s. Catches increased rapidly throughout the 1960s and early 1970s, peaking at 7,900 metric tons (t) in 1974. Catches declined during the rest of the decade, due to ineffective fisheries management policies and increasing disruptive civil disorders. Even so, the shrimp catch still totaled about 4,000 t in 1979. The shrimp industry was strictly controlled by the Nicaraguan Government under General Anastasio Somoza. Government concessions to fish for shrimp were required. Many of the concessions were issued to individuals or companies with financial or family ties to the Somoza family.

Nicaragua's shrimp fishery declined precipitously after the Sandinista victory in 1979 (figure 1). Most of the fishing industry, including the shrimp fishery, was seized by the Sandinistas. The Somoza family's heavy investment in fisheries made the industry a prime target for nationalization. Many fishermen fled the country in shrimp and other fishing boats.[1] The Government nationalized processing plants, some partially owned by U.S. investors, and the remaining vessels. The nationalized units were combined under a new Government agency, the Instituto Nicaraguense de la Pesca (INPESCA). The Sandinista Government's performance in fisheries, however, proved to be an economic disaster. A productive industry which was a major source of export earnings steadily disintegrated. Observers report that the state-owned operations which acquired the remaining vessels and plants operated them poorly. Maintenance standards in particular declined. Some Sandinista officials, including important elements of INPESCA, felt that the country's fishing industry should focus more on the domestic market rather than on producing for export markets. As a result, the shrimp catch fell from 4,100 metric tons (t) in 1980 to only 1,000 t in 1986. Marginal increases have since been reported and the catch totaled 1,300 t in 1989 (appendix C and figure 1).

Much of the decline in the shrimp catch has occurred in the large Caribbean fishery which once dominated the industry (figure 1). Since 1988, Nicaraguan fishermen have actually been reporting larger Pacific catches. Nearly 70 percent of the 1989 shrimp catch, for example, was taken along the Pacific coast (appendix C and figure 1). The reason for the decline is unclear. It probably reflects both the extreme isolation of Bluefields and the Caribbean coast in general, as well as, the overall economic problems. One U.S. Embassy report indicated that the catch decline was due primarily to the great turmoil and administrative disruption which occurred along the Caribbean coast during the Sandinista period.[2] Hurricane Joan which devastated Bluefields in 1988 and damaged large numbers of fishing vessels has also been a contributing factor.[3]

The new democratically elected Government of Doña Violeta Chamorro is concerned about the decline in major fisheries. The new INPESCA team plans to implement new fishery management plans to improve yields and are currently studying various possible options.[4] Only limited information is available on existing management regulations. The Government currently enforces a Caribbean coast seasonal closure from May 1 to June 30 and year-round restrictions on collecting seedstock and juveniles in estuaries along both coasts.[5]

The Chamorro Government is also about to complete the process of privatizing both state-owned vessels and processing plants. Government officials believe that by the end of 1992, they will have sold off all assets for which buyers can be found.[6] In most instances shrimp trawlers are being sold to the skippers at generous terms. Many of the trawlers, however, even relatively new trawlers, are reportedly in poor condition. Some of the plants are in better condition, especially the new Bluefields plants built with Norwegian assistance to replace the hurricane-damaged facilities.

II. SPECIES

A wide variety of shrimp species are reported by Nicaraguan fishermen as they operate in both the Caribbean and Pacific. Details on the English and Spanish names for these species is available in appendix B.[7]

A. Caribbean

The Caribbean fishery is dominated by two species of pink shrimp, although a white shrimp species is also of some importance.

Penaeus notialis[8] and ***P. brasiliensis***[9]: Both these species of pink shrimp are offshore species, occurring around cays and islands at depths of about 50 meters. The fishery usually begins in October and continues until the following May. The best grounds lie within the triangle formed roughly by Punta de Perlas, Islas de Maiz, and Punta del Mono. The authors know of no farm trials using these species in Nicaragua.

P. schmitti: This white shrimp is seasonally important. The adults leave the coastal estuaries when the heavy rains begin in July and move off shore. The fishery is conducted from August through December. The grounds are distinct from those for the pinks and extend from Cabo Gracias a Dios past Puerto Cabezas to Prinzapolea. This white shrimp, which is found in relatively shallow waters, is only fished during daylight hours. The trawlers are sometimes deployed just outside the breaker line in water as shallow as 9-12 meters. Several growers in other Caribbean/ Atlantic coast countries have attempted to culture this species. Results have been generally disappointing, but the Cuban Empresa Nacional de Camaronicultura (ENC) is reporting increasing success.[10]

P. aztecus: Catches of this brown shrimp decline south of Mexico, but small quantities are taken off Nicaragua in the same area and during the same season as *P. schmitti*. They are caught somewhat further from shore and are fished at night. The authors know of no Nicaraguan trials using this species

Photo 1.--*Nicaragua. The 1990 election of President Violeta Chamorro has dramatically changed the business climate, attracting potential investment groups to the shrimp industry. © Randolf Wells*

and growers in other Caribbean/Atlantic coast countries have reported poor results in trial runs.

B. Pacific

The Pacific fishery focuses primarily on three species of white shrimp, although a variety of other species are also taken.

P. occidentalis, P. stylirostris*, and *P. vannamei: Three species of white shrimp dominate the capture fishery. Much of the larger shrimp taken are either *P. occidentalis* or *P. stylirostris* while *P. vannamei* catches include a wider range of sizes. Few reports are available to the authors on pond performance. Most Central American growers report their best results with these white shrimp species, especially *P. vannamei* and *P. stylirostris*. One INPESCA report suggest that the harvest was primarily *P. stylirostris* and *P. occidentalis* along with smaller quantities of *P. vannamei*.[11]

P. spp.: Trawler fishermen also report taking small quantities of brown (*P. californiensis*) and pink (*P. brevirostris*) shrimp. The authors know of no Nicaraguan pond trials using these species, other than groups using pl naturally occurring in the water.

Non-*Penaeids*: Two species of small shrimp are sometimes taken in commercial quantities, seabobs (*Xiphopenaeus riveti*) and carabali (*Trachypenaeus byrdi*) shrimp. The authors know of no pond trials using these species.

III. AQUACULTURE INDUSTRY

Nicaragua currently has virtually no aquaculture industry, despite some development efforts. The Instituto de Fomento Nacional (INFONAC)[12] initiated some preliminary work with aquaculture in 1977.[13] The Instituto Nicaraguense de la Pesca (INPESCA), INFONAC's successor agency, has expressed an interest in promoting an aquaculture industry and established a Dirección de Acuicultura (DA) in 1984. The DA opened a small hatchery at the General Omar Torrijos Herrera Estación Piscícola, about 20 km north of Managua. Researchers reportedly worked with two imported species (tilapia and carp) and one indigenous species (colasoma). Probably reflecting the Cuban influence, INPESCA has assessed the possibility of stocking irrigation reservoirs.[14] The Government's limited financial capability and the protracted insurgency prevented any substantial progress in developing aquaculture projects during the Sandinista period (1979-90). Cultured fish harvests were probably less than 20 t in 1989.[15] The new Chamorro Government is currently preparing an aquaculture development program, but like the Sandinistas, faces the difficulty of limited financial resources.

Nicaragua has the potential for developing a small aquaculture industry, but growers face some impediments. Abundant freshwater resources exist in the Managua, León, and Chinandega areas. Other important physical conditions are reportedly favorable. Lake Nicaragua, the largest body of freshwater in Central America, and Lake Managua could be used for finfish pen or cage culture. Some observers believe that mussels and oysters can be successfully cultured.[16] The mangrove estuaries along the Pacific coast could provide excellent sites for both shrimp and oyster culture. There are, however, some natural limitations. Along the Caribbean coast rainfall is sometimes so heavy that salinities are subject to sharp fluctuations. Salinities sometimes fall to such low levels, for example, that oysters would die. Observers are also concerned about the heavy use of insecticides and other agricultural chemicals which has affected areas along both coasts. Freshwater lakes and rivers, including Lake Managua, have reportedly been polluted not only by insecticides, but also by urban sewage and industrial wastes. The shortage of adequately trained technicians is another serious problem faced by the industry.

INPESCA is currently preparing a new national aquaculture plan.[17] Given the staggering problems faced by the Chamorro Government, a significant allocation of resources to promote aquaculture is unlikely at this time. INPESCA has reportedly even had to close its aquaculture research station. The only projects with prospects at this time are those producing for export markets because they could attract private investment capital. As a result, INPESCA's aquaculture development plan will reportedly focus heavily on shrimp culture. This means that the only significant aquaculture projects that will be initiated in the next few years will probably be for marine shrimp farms.

IV. GROWING CONDITIONS

Growers could use sites along both the Pacific and Caribbean coasts, but conditions appear most favorable along the Pacific.

Pacific: INPESCA biologists report several factors which suggest that shrimp culture projects could prove successful in Nicaragua, especially along the Pacific coast. Climate, estuarine environments, water quality, and soil characteristics are all reportedly favorable. Pacific growers also have the advantage of available *P. vannamei* postlarvae (pl) to stock their ponds. Despite the generally favorable conditions, Nicaraguan shrimp farmers, like growers elsewhere in Central America, must contend with dry and rainy seasons. Both rainfall and salinities fluctuate sharply between these two seasons. Salinities during the dry season (December-May) range from 30-35 parts-per-thousand (ppt) and during the rainy season (May-December) from 1-20 ppt.[18]

Caribbean: Some early shrimp culture project assessments were conducted in the Laguna de Perlas along the Caribbean coast in the early 1970s, however, no information is available to the authors on their findings. Virtually all growers in other Central American countries (Guatemala, Honduras, Costa Rica, and Panama) have located their farms along the Pacific coast.[19] Some observers believe that conditions along the Caribbean coast, are reportedly less favorable, but only a few details are available to the authors. Some report that heavy precipitation levels could create pond management problems. Others have expressed concerns over limited tidal exchanges. Caribbean growers will have a special difficulty obtaining appropriate postlarval seedstock because *P. vannamei* is a Pacific species. The lack of interest among potential growers may be largely due to the isolation of the Caribbean coast and lack of basic infrastructure. Growers may ultimately begin to develop Caribbean sites as well. The significant estuarine system and abundant rainfall suggest that shrimp can be cultured along the Caribbean.

V. AREA

Nicaragua appears to have one of the largest areas in Central America suitable for shrimp culture. **Pacific coast**: INPESCA conducted a preliminary study in 1988 to assess the country's potential to culture shrimp. Existing maps were used to estimate the area of salt flats. INPESCA believes that the best sites are located along the Pacific coast and estimates that nearly 40,000 hectares (ha) are suitable for shrimp culture.[20] More than half of the potential sites (28,200 ha) are located along the northwestern coast, especially in the Estero Real area.[21] Sites also exist in the Puerto Sandino and Estero Padre Ramos area.[22] One observer who visited Nicaragua in 1991 was particularly impressed with the Estero Real area, but found elevated salinities at some other sites--especially near Puerto Sandino.[23] Potential development will be slowed by the lack of infrastructure, a more severe problem than faced by growers in other Central American countries.

Caribbean: No details are available concerning the potential area along the Caribbean. It is likely that many suitable sites exist. The Caribbean infrastructure, however, is even more primitive than that faced by Pacific-coast growers. This lack of basic infrastructure will severely limit Caribbean-coast development, even if suitable sites are identified.

The authors have no way of assessing the INPESCA estimate of potential Pacific sites. They may be unrealistically high and appear to be based primarily on rough approximations of existing terrain data. A reliable study would require detailed on the ground surveys to fully assess the wide range of water and soil characteristics needed to properly assess site suitability. The authors know of no such comprehensive study which has been released by INPESCA. Individual investor groups, however, have almost certainly conducted surveys of specific areas. It is clear that there is a substantial area of excellent Pacific sites available to growers in Nicaragua. The overall potential area may actually exceed current INPESCA estimates if potential Caribbean sites were included.

The authors were unable to obtain firm data on the area of ponds actually constructed in Nicaragua. The area appears, however, to be quite small. One 1990 report suggested that there were only about 90 hectares (ha) of ponds, but a substantially larger area of estuarine enclosures--perhaps as much as 1,000 ha (appendix D). Considerable care should be taken in assessing reports from Nicaragua as it is often not clear if observers are referring to ponds or rudimentary estuarine enclosures.

Information on the area of ponds under construction or planned for construction is also not available. INPESCA has released some information on applications from interested investment groups and reports that as of early 1991 it had received applications from 29 private groups to build 10,500 ha of ponds, almost all in the Estero Real area. No growers have yet submitted applications for Caribbean coast farms. It is unclear how many of these applications come from adequately financed groups that are actually able to implement their plans.

Scattered reports describing specific projects suggest that 2,000-3,000 ha of ponds may be built during the next few years.

VI. ECONOMIC AND POLITICAL DIFFICULTIES

Nicaraguan growers have made little progress in developing the country's substantial potential to culture shrimp. The change of Government in 1990 is allowing private investors for the first time to participate in the shrimp culture industry. Many economic and political difficulties, however, confront the private groups which have expressed interest. Observers stress that problems obtaining credit are the most serious current problem.

1979-90: The Sandinista victory in 1979 brought to power a Government that was basically hostile to private investors. While not specifically prohibited from culturing shrimp, few investors were willing to make significant investments in the contentious economic and political climate created by the Sandinistas. The cooperatives and groups of artisanal fishermen favored by the Sandinista Government, however, reported only marginal success. The civil disorders and increasing economic problems which developed in the mid-1980s complicated the small shrimp culture pojects initiated by the Government.

1990-92: The electoral defeat of the Sandinistas in 1990 has brought to power a Government more favorably disposed to private investment. (See: Section "XIV. Government Role.") As a result, nearly 30 investment groups have applied for permission to build shrimp farms. Nicaragua's pressing economic problems, however, limit the country's ability to expand the new industry. Problems include severe inflation and the highest interest rates in Central America. Many report that the single greatest problem is financing the new projects being planned.[24] Even qualified growers are reportedly having trouble obtaining credit. Despite the change of Government, the political and economic situation is still unsettled. The continuing influence of the Sandinistas is proving to be a serious destabilizing force. Many investors continue to be cautious about making substantial financial commitments.[25] Even so, several groups are very optimistic about the country's potential.

VII. EARLY PROJECTS

Several different groups have attempted to culture shrimp in Nicaragua. Some of the early efforts included:

Japanese project: Efforts to culture shrimp in Nicaragua began in 1975 along the Pacific coast with assistance from the Japanese Government. The Japanese research included work on both ponds and floating cages at Padre Ramos. The Japanese withdrew their technical advisor in 1978 when civil disorders in the area made it impossible to continue the work.

Domsea project: The U.S. Domsea Company planned a $7-million project with INFONAC at Laguna de Perlas along the Caribbean coast in 1977.[26] The company decided, however, against actually committing funds. Technicians assessing the Laguna de Perlas concluded that the limited tidal range and the lack of a Caribbean species suited for culture made the project infeasible.

INFONAC project: INFONAC also studied the idea of using the fill resulting from dredging operations in the Laguna de Perlas to build enclosures for culturing *P. schmitti*. The attempt did not prove successful due to the inexperience of a foreign technician involved and the limited range of the tidal exchange.

Callejas-López: The Callejas-López family opened an extensive 40-ha shrimp farm during 1978. The farm was located near Puerto Morazán along the Pacific coast in Chinandega Department. The project was financed by the Banco Central de Nicaragua. The farm was abandoned in 1979 after the owners experienced a variety of technical problems which they were unable to resolve because of inexperience in growout techniques. The unstable political situation contributed to their problems.[27]

Cooperative project: A cooperative group began extensive operations in an abandoned salt-evaporation pond near Puerto Sandino. The project obtained financing from the Banco Nacional de Desarrollo (BND) in 1980. The project failed, however, because of the cooperative's limited technical and administrative capability and the ponds were abandoned.[28]

Estuarine enclosures: Artisanal fishermen at Puerto Morazán near Estero Real in Chinandega Department during 1981 attempted to use the "tapo" system developed in Mexico for enclosing estuarine areas. The group obtained financing from the BND. Harvests of about 10 t were reported in 1983.[29] The project was not successful commercially, however, primarily due to the inexperience of the individuals involved and security problems in the area. The project was abandoned in 1983.[30]

VIII. POSTLARVAL SEEDSTOCK

Nicaraguan growers have access to a substantial wild pl resource, but no detailed studies assessing that resource are available to the authors. Thus no reliable estimates can be made projecting the area of ponds which could be stocked with wild postlarvae. It is clear, however, that Nicaraguan growers can stock large numbers of farms with wild seedstock. One observer believes that the relatively large quantities of pl available in Nicaragua will give local growers a significant advantage over others elsewhere in Central America.[31]

Pl availability is seasonal. The greatest number of *P. vannamei* pl are usually available at the end of the rainy season (especially October and November). After the dry season begins (December), pl of another white shrimp species, *P. stylirostris*, become more plentiful.[32]

Growers currently operate extensive systems and primarily rely on the pl naturally present in the water. Some of the more advanced operations are supplementing the pl already present by adding some additional pl collected in the local estuaries. The new semi-intensive farms planned by private investors, however, will require larger quantities of postlarvae. Artisanal fishermen have been collecting pl for some time. They are currently supplying growers with limited quantities of pl and should be able to adequately supply many of the new farms that are planned for construction. Such an assessment, however, is speculative because the size of the pl resource is largely unknown.

INPESCA is considering a hatchery program to supplement wild collection. Nicaragua currently has no shrimp hatcheries. Some research on larviculture is being conducted at the Universidad Centroamericana (UCA).[33] INPESCA has authorized the construction of two small shrimp hatcheries, each with the capacity of producing about 35 million *P. vannamei* pl per year. The hatcheries will be located at Playa de Jiquilillo (Chinandega) Playa de Miramar (León).[34] INPESCA also plans to build a large new hatchery capable of supplying 80 million pl per month.[35] Another hatchery project has been mentioned in press reports as part of a Spanish-financed project near Playones Catarina.[36]

Nicaraguan collectors are supplying wild pl to growers in other countries. INPESCA launched a pl sales effort in 1985. It signed an agreement with a Peruvian company, Empresa Langostinera Tumpis, to supply pl which were very scarce in Peru and Ecuador at the time.[37] INPESCA hoped to earn about $1.5 million annually from the sale of pl, but problems with air transport caused considerable pl mortalities and the project had to be terminated. Another project, however, has recently begun supplying pl to rapidly expanding Honduran growers.[38] The Centro de Acopio en Puerto Sandino began operating in 1991 and projects sales of at least 3 million pl annually.[39]

IX. METHODS

Nicaraguan growers initially experimented with various basic systems. Many of the new private groups currently planning to enter the shrimp culture industry are reportedly considering more sophisticated semi-intensive operations.

Enclosures: Cooperatives operated the earliest Nicaraguan shrimp culture projects which were simple estuarine enclosures employing the Mexican "tapo" system. The cooperatives closed off portions of estuaries where shrimp could be cultured. The system utilized no additional inputs such as fertilization or feed. The cooperatives reportedly used 130 ha of estuarine enclosures to harvest 28 t of shrimp in 1987. They have expanded the project and reportedly harvested about 140 t of shrimp in 1989 from 600 ha of enclosures.[40] One INPESCA report suggests that harvests are primarily *P. stylirostris* and *P. occidentalis*, but lesser amounts of *P. vannamei* are also harvested.[41] The cooperatives expanded their area and in 1990 as many as 1,000 ha of enclosures were being used. Yields were exceedingly low, but likewise production costs were much lower than for semi-intensive systems. Some of the projects have closed, but a growing number are reportedly active.

Extensive: Early growers constructed primitive ponds without any form of compacting or leveling the bottom. Several projects have used relatively large ponds. Some cooperatives, for example, built large ponds with only one concrete gate to both fill and drain the water. Such an arrangement, while simple and inexpensive to construct, complicated pond management and in many instances restricted operations to the rainy season.[42] Ponds are filled through tidal action. The coops supplement pl naturally present with pl collected in the wild, but there is no supplemental feeding or pumping of water. Harvests are conducted every 2-3 months and include shrimp up to 132 mm in length.

Semi-intensive: Many of the new private entrants in the industry are now considering more sophisticated semi-intensive pond management systems. The initiation of actual semi-intensive systems, however, will be difficult until growers can obtain domestically produced or imported feed. The authors have no details on any actual semi-intensive farm, but several groups are reportedly planning to begin construction in 1992.[43]

No Nicaraguan company currently produces shrimp feed. One report suggested that the Sandinista Government was considering the construction of a shrimp meal plant at San Juan del Sur.[44] Such a plant could produce a valuable ingredient for any future domestic shrimp feed production. One animal feed producer reportedly planned to begin production of a shrimp ration in 1991.[45] No information is available on actual results. The absence of domestic feed mills producing shrimp rations is a serious problem and is restricting the ability of new investment groups to initiate semi-intensive methods.

Nicaraguan growers will benefit from the rapidly developing Honduran shrimp culture industry. The Central American peace process and the change of government in Nicaragua have substantially increased trade and labor movement across the border. Nicaraguan investors can draw upon the methods adopted in Honduras and the substantial technical experience that Honduran growers and technicians have developed with semi-intensive methods. If the economy normalizes in Nicaragua, experienced Honduran technicians will be available for employment in nearby Nicaraguan farms. Thus Nicaraguan growers will not have the enormous problem that growers elsewhere in Central America faced--launching a new industry with out access to locally available technical support and experience.

X. FARMS

Only limited information is available on Nicaraguan farm projects. INPESCA and cooperatives dominated the limited efforts made during the 1980s. With the change of Government in 1990, several new private groups, some with Sandinista participants, are now leading the industry's development. Some of these groups hope to begin construction of modern farms in 1992.

A. INPESCA

INPESCA's Dirección de Acuicultura began giving increased attention to shrimp culture in 1987. Given the Governments's financial situation, only limited funds were available to finance shrimp culture projects. As a result, officials concluded that the estuarine enclosure system was a viable alternative to more costly pond construction and was the best initial approach for Nicaragua. INPESCA reported some limited success, but had difficulty pursuing the project because of the level of hostilities in the frontier areas where preliminary studies were conducted during the late 1980s.

Cooperative farms: INPESCA provided technical assistance to cooperative groups. (For details see Section "X. B. Cooperatives.")

INPESCA farm: INPESCA opened a pilot commercial project at Chinandega near Puerto Morazán (northwestern Nicaragua) in March 1990. The $1 million farm consists of eight ponds on a 60-ha site, including three growout ponds (two of 21 ha and one of 13 ha) and six nursery ponds (1 ha each). The nursery ponds are stocked at 5 pl per square meter (m^2). The pl are transferred to the growout ponds when they reach about 1 gram. The growout ponds are stocked at 2-3 pl per m^2. INPESCA is using extensive methods. The ponds are fertilized, but no supplemental feed is used as it is not available in Nicaragua. The farm manager, however, is reportedly looking for a domestic feed source so he could attempt semi-intensive operations.[46] The farm is operated by INPESCA's Centro de Investigaciones Pesqueras (CIP).[47] It is the most advanced shrimp farm to be built in the country and will serve as both a demonstration project and a research center. The CIP hopes to eventually produce about 100 t of shrimp annually.[48] The water exchange rate is 8 percent daily. INPESCA reported in 1990 that disappointing harvests were achieved during dry season trials, but harvested about 23 t in 1990, which would mean annual yields of about 0.4 t per hectare.[49]

Farm managers had anticipated a 185 t harvest in 1990.[50] The shrimp are harvested when they reach 18 grams (gm), but the pond operators say that they would aim at 25-30 gm shrimp if they were able to obtain feed.[51]

INPESCA salt pond project: Another INPESCA effort is an integrated salt pond project. INPESCA is experimenting with an integrated salt, *Artemia*, and shrimp pond program. A Costa Rican specialist, Roman Odio, in 1989 help set up an experimental system funded by the International Organization for Migration (IOM). The 400-ha project is located at Salinas Grandes in León Department along the Pacific coast. A mixture of San Francisco Bay, Great Salt Lake, and Macau *Artemia* was used.[52]

B. Cooperatives

Various cooperative projects are currently operating in the Puerto Morazán area. Four cooperatives with a membership of 93 fishermen initiated a part-time shrimp culture project in 1987. One report suggests that artisanal shrimp fishermen have been abandoning fishing to culture shrimp.[53] The cooperatives managed about 100 ha of water surface area with INPESCA technical assistance. (It is unclear whether the cooperatives are operating estuarine enclosures, extensive ponds, or a combination of the two. Some authors specify extensive ponds, but they may in fact be describing estuarine enclosures.) The BND provided \$0.2 million in financing and the cooperatives harvested about 14 t in 1987.[54] They used tidal exchanges to fill and exchange water. Pl naturally present in the water were supplemented with wild collection. New cooperatives entered the program in 1988, and nine cooperatives operated 232 of water surface area. The program is continuing to expand. Thirteen cooperatives were reportedly working 1,000 ha of surface area in 1990 and harvested about 130 t of shrimp.[55] Much of the harvest is small (60-80 count) shrimp.

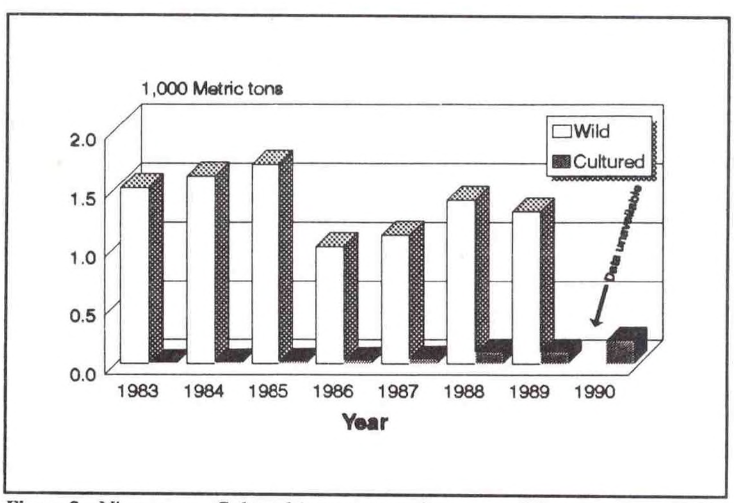

Figure 3.--Nicaragua. Cultured harvests constitute a small but growing part of the country's overall shrimp production.

C. Private projects

Private groups are actively entering the industry. One observer reports that "shrimp fever" is sweeping Nicaragua as investors rush to form commercial ventures.[56] INPESCA is reportedly granting 10-year leases for \$30 per hectare. Several groups are competing to stake their claim for the most promising sites. Disputes are arising between both private investors and different government agencies. One promising site, for example, have been claimed by both the national government and the local municipal government. Many of the new groups, however, are reporting serious problems obtaining adequate financing. Despite the difficulties, some groups plan on beginning pond construction in 1992.[57]

Puerto Morazán: Investors have built a farm at Puerto Morazán which currently has 25 ha of ponds. The farm uses pl collected in the wild which are stocked in nursery ponds at about 5 pl per square meter. When the shrimp reach about 1 gm they are transferred to growout ponds at 2-3 pl per square meter. The investors have major expansion plans.

Estero Real: Newspaper accounts indicate that a private group is considering a major commercial farm near Estero Real. Plans call for the developing a 1,500 ha site over the next few years. Information on the specific area of ponds planned is not available.

Playones Catarina: Three investor groups reportedly plan to build 500-ha farms at Playones Catarina with funds obtained through a Spanish aid program. The project includes a hatchery.[58]

Other groups: Several other private groups and cooperatives are planning to build farms.[59] One report indicates that as many as 500 ha of ponds were to be built during 1991 in the Estero Real area alone. The authors have, however, no confirmation that such a large area of ponds were actually built.

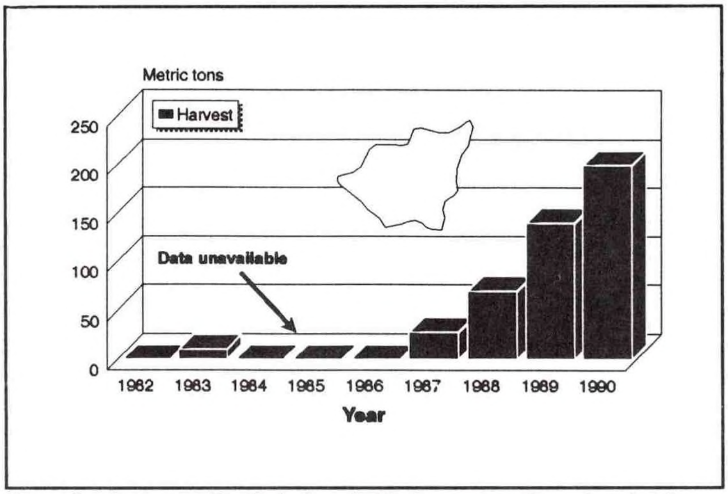

Figure 4.--Nicaragua. The limited available data suggest that cultured shrimp harvest are increasing.

XI. HARVESTS

The authors have no reliable data on Nicaraguan harvests. While there have been some shrimp produced by various cooperative groups, the quantities have been small and harvested at irregular intervals. The cultured harvest thus constitutes only a small share of the country's shrimp production, despite the decline of the trawler fishery (figure 3). The limited information available to the authors suggest that the 1989 harvests may have totaled about 140 tons (appendix D and figure 4). A few farms have reported somewhat higher 1990 harvests, but official data from Government sources is unavailable. The 1990 harvest may have reached 200 tons. No data is available to the authors on 1991 harvests.

Projecting future harvests is difficult because of the lack of detailed statistics. Nicaragua clearly has the potential to produce substantial quantities of cultured shrimp. The principal impediment currently appears to be the overall economic environment. Given the chaotic economic and political situation, it is likely that the industry will develop only slowly during the 1990s. If the Government can stabilize the economy, substantial progress could be made given the country's substantial potential. Even the most optimistic analysts, however, are unlikely to project harvests exceeding 5,000 t by the year 2000. With such a small area of existing ponds, it is hard to be overly optimistic. Given the enormous overall economic problems, many of the investor groups which have applied for permits may not be able to obtain needed credits to launch planned construction projects. As a result, it is not possible at this time to project substantial future harvests with confidence. Lower harvests ranging from 2,000-3,000 t by 2000 appear more plausible.

XII. EXPORTS

Shrimp used to be one of Nicaragua's principal export commodities. Shipments steadily fell during the 1980s as catches declined. (See: Section "I. Capture Fishery.") The industry was adversely affected by fishermen using their trawlers to flee the country, property seizures, Sandinista mismanagement, labor problems, escalating hostilities, the U.S. trade embargo, and other difficulties. As a result, exports plummeted from 2,600 t in 1980 to only about 100 t in 1988 (appendix F and figure 5). Shipments have since increased marginally to about 400 t in 1990 and incomplete data suggests shipments exceeding 500 t in 1991.[60]

United States: The United States is the principal market for Nicaraguan shrimp. Until the U.S. embargo in 1985, the United States was the only country where Nicaragua marketed significant quantities of shrimp (figure 5). Even during the embargo (1985-90), some shrimp was surreptitiously exported to the United States by shipping it through third countries (Guatemala, Honduras, Panama, and

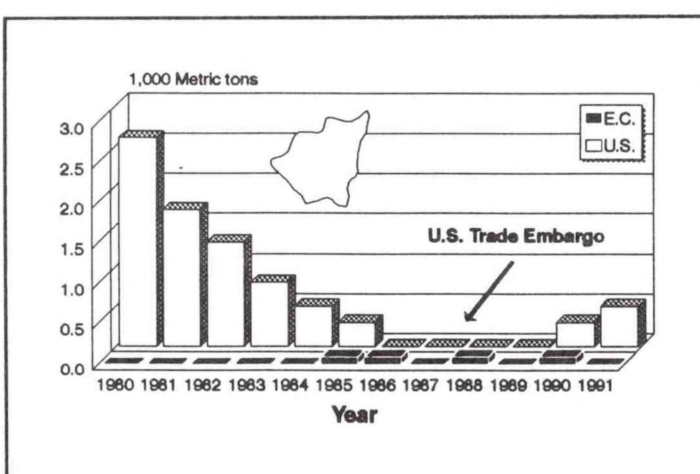

Figure 5.--Nicaragua. The United States is the principal market for Nicaraguan shrimp.

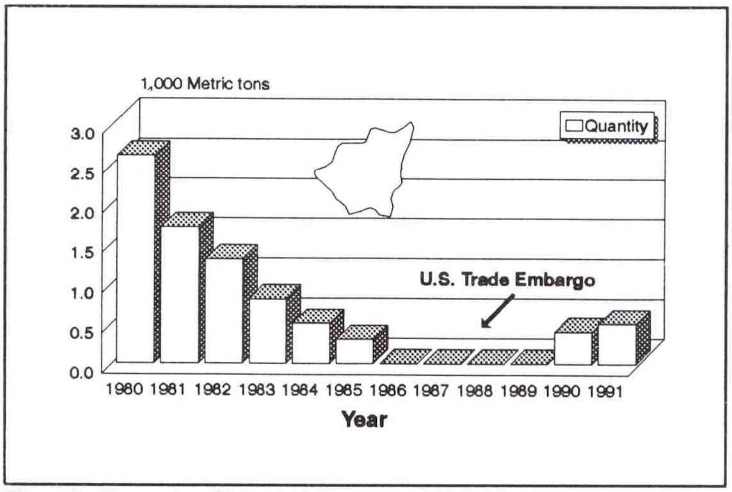

Figure 6.--Nicaragua. Shrimp shipments to the United States are slowly increasing since the removal of the U.S. trade embargo in 1990.

others).[61] The United States removed the embargo in 1990, but the virtual collapse of the country's fishing industry means that only small quantities of shrimp are now available for export. Shipments to the United States in 1991 totaled about 500 t valued at $3.4 million (appendix G and figure 6). Nicaraguan exporters should gradually increase shipments during the 1990s as the fishing industry begins to recover. Growers will benefit from the strong market for white shrimp in the United States where consumers consider it to be a premium product.

Europe: Nicaragua entered the European Community (EC) market in 1985 after the United States embargoed Nicaraguan products. Shipments to Europe were relatively small, however, only about 100 t per year through 1990 (appendix G and figure 4). The growing European market offers significant potential for expanded sales, although limited Nicaraguan production means only small quantities are available for export. Growers may also find it difficult, especially when only small quantities are involved, to contend with the complicated processing and labeling standards in the different EC countries.

Japan: Nicaragua does not export shrimp to Japan (appendix G). Even during the U.S. embargo, Nicaragua made no serious effort to enter the Japanese market. Growers are likely to have limited success in any future effort to enter the market. China already supplies large quantities of cultured white shrimp at relatively low prices.

Nicaragua should be able to increase shrimp exports during the 1990s, as a result of the political changes in 1990. Both fishermen and growers should report production increases in the new economic environment, providing additional product for export sales. The continuing economic and political turmoil, however, will limit the speed of recovery. The lack of investment capital in particular will impede the shrimp culture industry's development.[62] In addition, the fleet and processing plants have deteriorated significantly and considerable investment is needed to enable Nicaragua to resume significant shipments of export-grade shrimp.

XIII. LEGAL FRAMEWORK

Groups desiring to build shrimp farms must obtain authorization from INPESCA.[63] INPESCA has compiled a list of requisites that applicants must fulfill when planning new projects. These requisites include:

1. Application with basic data on the investment group and the location and size of the project
2. Legal basis of group
3. Project profile
4. Farm layout

Once the above is completed, the investment group has to advertize its plans in local newspapers. These requisites and copies of the newspaper articles are then delivered to INPESCA and within 90 days an economic feasibility study has to be filed. If the submitted materials meet the requirements, INPESCA will issue the appropriate authorization within 30 days.

Coastal areas up to the high tide line are considered to be state property.[64] Shrimp culture leases for this land are valid for 10 years and can be renewed for an additional 10 years. The group must pay a $30 fee per ha and a 1 percent annual fee on income which will be used by INPESCA to finance shrimp culture research and to protect natural resources. INPESCA is also responsible for regulating water usage and outflow so as to minimize pollution. INPESCA requires that any harvested shrimp be processed at a Nicaraguan packing plant.[65]

XIV. GOVERNMENT ROLE

Various Nicaraguan Government agencies are involved in the shrimp culture industry. Several agencies are promoting the industry's development.

INPESCA is the lead agency and its activities are described above. INPESCA's plans for a new national aquaculture program will reportedly give a heavy emphasis to shrimp culture.[66] (See: Section "III. Aquaculture Industry.") INPESCA is reportedly focusing primarily on shrimp culture with the private sector to play the lead role.[67] The Fondo Nicaraguense de Inversion (FNI) has provided some investment capital, some of which has been channeled through the FOPEX program. At least one agency, however, has expressed concern over the industry's development. The Instituto Nicaraguense de Recursos Naturales y del Ambiente (IRENA) is concerned about the possible destruction of mangroves during the construction of ponds. IRENA issued regulations in January 1991 protecting mangroves.[68]

The Government's role has changed dramatically with the 1990 electoral defeat of the Sandinistas and the assumption of power by a new Government committed to private enterprise. This has created greatly expanded interest in Nicaragua's potential to culture shrimp. INPESCA will now play a regulatory and promotional role rather than the central role in the industry's development. The Government has implemented new legislation to attract private investors. Investors can now lease up to 500 ha at very low rates. One observer reports that 29 companies have applied for such concessions.[69] Some of the new private groups are even reportedly composed of former Sandinista Government officials, apparently deciding to experiment with venture capitalism. Despite the shift in emphasis, the new Nicaraguan Government continues to believe the shrimp culture industry offers significant potential and has directed small amounts of its scare resources to support the industry's development.

The Nicaraguan Government has established nature preserves along the Pacific coast.[70] The areas covered appear to include some of the best potential sites for shrimp farms. Affected areas include: Estero Real, the Estero de Padre Ramos, the Estero de Salinas Grandes, the Estero de Santa Lucía, and the Bocana de las Peñitas. Investors have expressed interest in developing sites in several of these areas. IRENA is responsible for administering these reserves. The Government has created a commission composed of IRENA, INPESCA, and other involved agencies to regulate economic activities such as shrimp culture within the reserves.[71]

XV. FOREIGN ASSISTANCE

The Nicaraguan Government has obtained some assistance from foreign countries and multinational organizations. Foreign assistance during the Sandinista period was obtained by INPESCA which it used for its own operations and to assist cooperative groups. Currently investor groups are obtaining some financing through various foreign assistance programs. Foreign donors can fund private sector development through the Government FOPEX program.

China: The joint Nicaraguan-Chinese cooperation program includes a shrimp culture project. China was reportedly prepared in 1988 to finance a 100 ha shrimp farm.[72] No further details, however, are available on this project and it is not known if the 1990 change of government affected the Chinese willingness to aid Nicaragua.

Spain: The new Nicaraguan Government in 1990 announced that a $41 million Spanish development loan would include a segment to finance a shrimp culture project.[73] INPESCA reports that $18 million has been earmarked for shrimp culture. The loan terms are highly favorable, 5 percent interest with a 7-year grace period.[74] The funds are designated to build and equip three 500-ha farms at Playones de Catarina in the Gulf of Fonseca area. The project also envisions the construction of a hatchery capable of producing 120 million pl per year and a shrimp packing plant. Both cooperatives and investors are eligible to participate and the funds will be channelled through Nicaraguan banks.

Sweden: Some funds provided by the Swedish Government has reportedly been used for a shrimp culture projects.

European Community: See OLDEPESCA.

FAO: FAO has previously funded a project to assess the area suitable for shrimp culture. FAO conducted a small $0.2 million program in 1991 to assist INPESCA identify the best sites at Estero Real and to help plan an industry promotion program.[75]

OLDEPESCA: Nicaragua participates in the 4-year (1991-95) Programa Regional de Apoyo al Desarrollo de la Pesca (PRADEPESCA), partially financed by the European Community and coordinated by the Organizacion Latinomaericano para el Desarrollo Pesquero (OLDEPESCA). PRADEPESCA has a regional marine and freshwater shrimp culture project focusing on both hatchery and growout work.[76] The project in Nicaragua sponsors work at the INPESCA Puerto Morazán farm. Research and training activity are utilizing 2 ha of ponds and the lab and dormitory at the farm. The project includes a variety of other components including extension work, technical courses, and scholarships for foreign study. The EC has provided $0.4 million for the Nicaraguan component of the project.[77]

XVI. TECHNICAL CAPABILITY

INPESCA is the principal Nicaraguan insitution known to be conducting aquaculture research. INPESCA's research arm is the Centro de Investigaciones Pesqueras (CIP). The CIP's activities have been very limited, however, because of severe budgetary constraints. The CIP's primary aquaculture research facility is the National Freshwater Research Station. The CIP reportedly has had to close the station because of budgetary restrictions.[78] There is no comparable marine research unit. No information is currently available on any CIP research that may have been conducted at the agency's Puerto Morazán shrimp farm or the various cooperative projects. The authors are unsure if any such work has been published. Some research has also been conducted at the Universidad Centroamericana (UCA).[79]

INPESCA reportedly sent a number of individuals for overseas technical training during the Sandinista period. Details on their experience and technical capability, are unavailable, but they probably received basic shrimp culture training. Many of these individuals are reportedly at present unemployed.[80] While these individuals are probably qualified to work as technicians, they have little experience and apparently did not receive advanced degrees. Investors will probably have to hire foreign specialists, adding to operating costs.[81]

XVII. OVERVIEW

Nicaragua has one of the largest potentials in Central America to culture shrimp. Some observers believe that Nicaragua has a substantial area of suitable sites with excellent growing conditions. While few Nicaraguans have experience with shrimp culture, growers will be able to draw on the infrastructure, technology, and experience developed at farms in Honduras and other Central American countries. Growers will also be able to employ the technicians trained during the Sandinista period. INPESCA believes that development of a shrimp culture industry is vital to the diversification of the country's fishing industry and can make an important contribution to the national economy by increasing export earnings.

INPESCA under the new Chamorro Government is currently preparing revised plans to promote shrimp culture. Details are not available, but given the Government's current fiscal situation, significantly expanded Government investments or promotional activities appear unlikely. INPESCA officials report, that the new program will instead rely heavily on private investment, including a role for foreign investors. A substantial number of both domestic and foreign investors have expressed an interest in the industry. Despite the change in government, both Nicaraguan and foreign investors, however, continue to be wary of committing funds, given the continued importance of the Sandinistas, strikes, political uncertainty, and the current economic situation.

Nicaragua clearly has the potential to produce substantial quantities of cultured shrimp. The principal impediment currently appears to be the overall economic environment in Nicaragua. Given the chaotic economic and political situation, it is likely that the industry will develop slowly during the 1990s. Actual projections are difficult to make. Only a small area of ponds is currently in operation and the authors do not yet have confirmation of significant construction projects. If the Government can stabilize the economy, substantial progress could be made given the country's potential. Even the most optimistic analysts, however, are unlikely to project harvests exceeding 5,000 t by the year 2000. Given the enormous overall economic problems, lower harvests ranging from 2,000-3,000 t appear more plausible at this time.

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ENDNOTES

SECTION I. (Capture Fishery)

1. Government officials report that Nicaragua lost over half its fishing fleet and many of the remaining vessels were not serviceable. "Nicaragua Builds Up Her Fleet," *World Fishing*, March 1982.

2. U.S. Embassy, Managua, January 21, 1983.

3. Lee Hockstader, "Cuba Helps House Nicaraguans Hit by Storm," *The Washington Post*, August 31, 1989, p. A44.

4. Milton Brecino, INPESCA, personal communications, February 12, 1992.

5. INFOPESCA, *Noticias Comerciales*, May 20, 1991. Pl collectors must obtain special INPESCA permits.

6. Brecino, *op. cit.*

SECTION II. (Species)

7. More complete biological information on these species is available in Dennis Weidner, Tom Revord, and Randy Wells, "Latin American Shrimp Culture, 1990-2000," *International Fishery Report*, in press.

8. Much of the literature describing Nicaraguan species refers to *P. duorarum*. That species was once considered to include two subspecies which are nowe generally regarded as distinct species. *P. duorarum duorarum*, commonly referred to as *P. duorarum*, occurs along the Atlantic/Gulf of Mexico coast of the United States and the Gulf of Mexico/Caribbean coast of Mexico. South of Quintana Roo in Mexico, *P. duorarum* becomes less common. Along the Central American coast, including Nicaragua, *P. duorarum notialis*, commonly referred to as *P. notialis*, is the dominate species.

9. *P. brasiliensis,* is often referred to as a brown shrimp in the United States.

10. Dennis Weidner and Randy Wells, "Cuban Shrimp Culture," *International Fishery Report*, in press.

11. The actual breakdown of the harvest was *P. stylirostris* (40 percent), *P. occidentalis* (34 percent), *P. vannamei* (14 percent), and other species (12 percent). INPESCA, "Perspectivas," *op. cit.*

SECTION III. (Aquaculture Industry)

12. The fishery functions of INFONAC were assumed by INPESCA after the 1979 Sandinista victory.

13. A now somewhat dated review of Nicaraguan aquaculture is available in INPESCA/CIP, "La Acuicultura en Nicaragua," *Revista Latinoamericana de Acuicultura*, December 1980, pp. 7-12.

14. "Aprovechamiento de micropresas en Nicaragua," *Revista Latinoamericana de Acuicultura*, September 1984, pp. 6-7.

15. FAO, "Aquaculture Production, 1986-89" *FAO Fisheries Circular*, No. 815, Rev. 3, July 1991.

16. D. Mejia and X. Poveda, "Posibilidad de cultivo de ostra y mejillon en Nicaragua," *Industrias Pesqueras*, July 1, 1980, p.9.

17. James Avault, Louisiana State University, item 16.5.39, *World Shrimp Farming*, May 1991.

SECTION IV. (Growing Conditions)

18. Avault, *World Shrimp Farming, op. cit.*

19. Belize appears to be the only Central American country with a commercially successful Caribbean farm. For details see Randolf Wells and Dennis Weidner, "Belizian Shrimp Culture," *International Fishery Report*, in press. Despite the problems associated with culturing shrimp along the Caribbean coast, such development should not be ruled out for the future. Growers in Colombia, for example, have achieved considerable success along the Caribbean coast report some of the most profitable farms in Latin America. Dennis Weidner and Tom Revord, "Colombian Shrimp Culture," *International Fishery Report*, (IFR-91/90), December 15, 1991.

SECTION V. (Area)

20. INPESCA, "Perspectivas de la Camaronicultura en Nicaragua," unpublished report. Other observers estimate about 20,000 hectares. U.S. Embassy, Managua, March 31, 1990. The INPESCA study (TCP/NIC/6759) was financed by FAO as part of its technical assistance program.

21. This area of northwestern Nicaragua is adjacent to Honduras' small Pacific (Gulf of Fonseca) coast where all of the highly successful Honduran farms are located. Development of Nicaraguan sites will be aided by the growing Honduran infrastructure as well as the technology and experience that Honduran technicians are developing. For details see Dennis Weidner, "Honduran Shrimp Culture," *International Fishery Report*, (IFR-91/21), March 29, 1991.

22. INPESCA, "El Cultivo de Camarones en Nicaragua," *Simposio Centroamericano Sobre Camaron Cultivado*, Honduras, April 24-26, 1991.

23. Al Solorzano, personal communications, January 13, 1992.

SECTION VI. (Difficulties)

24. Ing. Juan Andrés Vega Durand, Universidad Centroamericana (UCA), personal communications, March 9, 1992.

25. Shirley Christian, "The Nicaraguan Tinderbox: Arms and Anger," *The New York Times*, March 17, 1992, p. A10.

SECTION VII. (Early Projects)

26. "Domsea Looks to Latin America," *Fish Farming International*, December 1977.

27. INPESCA, "El Cultivo," *op. cit.*

28. INPESCA, "El Cultivo," *op. cit.*

29. "Gran Exito de un Proyecto de Crianza Extensiva de Camarones en Nicaragua," *Tecnica Pesquera*, January 1985, p. 21.

30. INPESCA, "El Cultivo," *op. cit.*

SECTION VIII. (Postlarval Seedstock)

31. Solorzano, *op. cit.*

32. James W. Avault, Jr., "Trip Notes - Aquaculture, Nicaragua," unpublished trip report, January 1991.

33. Ing. Juan Andrés Vega Durand, Universidad Centroamericana (UCA), personal communications, January 20, 1992. It is not clear if the UCA is just collecting data on larviculture or is preparing to conduct trial runs.

34. INPESCA, "El Cultivo," *op. cit.*

35. It is not know if this is the hatchery associated with the Spanish aid project or an additional hatchery project.

36. "Debt Round-up: Nicaragua," *Latin American Weekly Report*, December 20, 1990.

37. "Nicaragua Exportará Larvas de Camaron," *Aquamaris*, September 1985.

38. Weidner, "Honduran Shrimp Culture," *op. cit.*

39. INPESCA, "El Cultivo," *op. cit.*

SECTION IX. (Methods)

40. INPESCA, "Perspectivas," *op. cit.*

41. INPESCA, "Perspectivas," *op. cit.* The relatively high harvest of *P. occidentalis* is notable. Growers in most other countries report only negligible pond harvests of the species. The better results obtained in Nicaragua may reflect estuarine enclosures as opposed to extensive operations in ponds. *P. occidentalis* may perform better in the natural estuarine environment offered by the enclosures rather than in ponds.

42. Bartlett, *op. cit.*

43. Vega, *op. cit.*, March 9, 1992.

44. "Nicaragua Builds," *op. cit.* The current status of the project is unknown.

45. INPESCA, "El Cultivo," *op. cit.*

SECTION X. (Farms)

46. Peter Bartlett, personal communications, April 30, 1991.

47. One observer reports that the farm is a private undertaking, but that some of the investors are INPESCA personnel. Avault, "Trip Notes," *op. cit.*

48. "Experimental Shrimp Farm Inaugurated," *Barricada*, March 26, 1990.

49. INPESCA, "El Cultivo," *op. cit.* Another source provides slightly different data, 17 t from one of the growout ponds during the rainy season. Such results would mean yields of about 0.5 t per ha which would be acceptable for extensive operations.

50. INPESCA, "Perspectivas," *op. cit.*

51. Avault, "Trip Notes," *op. cit.*

52. Odio reports small harvests of large shrimp. He also says that a better quality salt was produced, acceptable to the local chlorine and soda industry. If the experimental project proves successful, salt imports could potentially be reduced or displaced entirely. Roman Odio, "Artemia in Nicaragua, *Larviculture and Artemia Newsletter*," March 1991, No. 19, p.39.

53. Avault, "Trip Notes," *op. cit.*

54. INPESCA, "El Cultivo," *op. cit.*

55. INPESCA, "El Cultivo," *op. cit.*

56. Bartlett, *op. cit.*

57. Vega, *op. cit.*, March 9, 1992.

58. "Debt Round-up: Nicaragua," *op. cit.*, December 20, 1990.

59. Avault, *World Shrimp Farming, op. cit.*

SECTION XII. (Exports)

60. Shipments of 500 t were made to the United States in 1991, but data on 1991 shipments to the EC are not yet available.

61. U.S. Embassy, Managua, September 25 and December 27, 1985.

62. Vega, *op. cit.*, March 9, 1992.

SECTION XIII. (Legal Framework)

63. Ley 356, May 31, 1988.

64. INPESCA, "El Cultivo," *op. cit.*

65. INPESCA, "El Cultivo," *op. cit.*

SECTION XIV. (Government Role)

66. Avault, *World Shrimp Farming, op. cit.*

67. Avault, "Trip Notes," *op. cit.*

68. IRENA has restricted mangrove cutting. Any activity utilizing mangroves or other estuarine resource must register with IRENA and obtain IRENA permits to cut mangroves. IRENA, regulations issued January 25, 1991.

69. Bob Rosenberry, "Nicaragua," *World Shrimp Farming*, July 1991, pp. 5-6.

70. Ley 1320, September 19, 1983.

71. INPESCA, "El Cultivo," *op. cit.*

SECTION XV. (Foreign Assistance)

72. ANN Managua, November 17, 1988.

73. Radio Sandino, Managua, May 24, 1990 and "Debt Round-up: Nicaragua," *op. cit.*

74. INPESCA, "El Cultivo," *op. cit.*

75. Rosenberry, "Nicaragua," *op. cit.*, pp. 5-6. The FAO project number is TCP/NIC/6759.

76. Julio César Aizprúa, "Países centroamericanos valorizan sector pesquero," *La Prensa*, September 12, 1991; OLDEPESCA, "Programa Regional de Apoyo al Desarrollo de la Pesca en el Istmo Centroamericano: Plan de Trabajo, Primer Año de Operaciones," July 9, 1991, pp. 40-52; and Armando Martínez Valdés. Asistente Ejecuativo, OLDEPESCA, personal communications, August 27, 1991.

77. INPESCA, "El Cultivo," *op. cit.*

SECTION XVI. (Technical Capability)

78. Avault, "Trip Notes," *op. cit.* INPESCA also reports disease problems at the Station. COPESCAL, "Informe de la Cuarta Reunion del Grupo de Trabajo Sobre Acuicultura," *FAO Informe de Pesca*, FIR/R464, 1991, p. 34.

79. Vega, *op. cit.*, January 20, 1992.

80. Solorzano, *op. cit.*

81. INPESCA, "El Cultivo," *op. cit.*

APPENDICES

Appendix A.--Nicaragua. Shrimp culture industry

Government agencies

Centro de Promocion de Exportaciones e Inversiones (CENPRO)
Address unavailable
Managua
NICARAGUA

Instituto Nicaraguense de la Pesca (INPESCA)
Km. 6½ Carretera Sur
Managua
NICARAGUA
Telephone: (505-2) 52017; 50423
FAX: (505-2) 52000

Instituto Nicaraguense de Recursos Naturales y el Ambiente (IRENA)
Apt. Postal 5123
Managua
NICARAGUA

Farms/observers

Maria Amanda Dekamen Ceradra
PO Box 2029
Managua
NICARAGUA

Nabisco Cristal
50 vrf - al sur
Managua
NICARAGUA

Research groups

INPESCA
See above

Universidad Centroamericana (UCA)
Dept. de Ecologia y Recursos Naturales
Apt. 69
Managua
NICARAGUA

Universidad Nacional Autonoma de Nicaragua (UNAN)
Departamento de Biologia
Leon
NICARAGUA

Appendix B.--Nicaragua. Selected shrimp species.

Species		
Scientific	English†	Spanish†
Marine		
Penaeus sp.	Penaeids/Shrimp	Penidios/Camarón
aztecus	northern brown	NA
brasiliensis	redspotted	rojo
brevirostris	crystal	rojo
californiensis	yellowleg	café
notialis	southern pink	rojo
occidentalis	western white	blanco
stylirostris	blue	blanco
vannamei	whiteleg	blanco
Pleoticus robustus	royal red	NA
Trachypenaeus sp.		
byrdi	carabali	tigre
faoea	indio	chacalín
kroyeri	NA	NA
similis	yellow roughneck	fijador
Xiphopenaeus sp.		
kroyeri	Atlantic seabob	tití/camaroncillo
riveti	Pacific seabob	tigre
Freshwater		
Macrobrachium sp.	Freshwater prawn	Camarón del río
acanthurus	NA	NA
americanum	NA	NA
carcinus	NA	NA
tenellum	NA	NA

† - FAO English terms. Commonly used Nicaraguan names appear in the Spanish column.
NA - Not Available
Sources: FAO, Species Catalogue: Volume 1 - Shrimps and Prawns of the World, Rome, 1980; and FAO, "Lista Preliminar de Especies Acuaticas Autoctonas Cultivadas o en Experimentación para su Cultivo en America Latina," Circular de Pesca (FIP/C846), December 1991.

Appendix C.--Nicaragua. Shrimp catch*, 1980-89

Year	Coast		Total**
	Caribbean	Pacific	
	1,000 Metric tons		
1979	2.7	1.3	3.9
1980	2.7	1.4	4.1
1981	2.1	1.3	3.5
1982	1.8	0.8	2.7
1983	1.2	0.3	1.5
1984	0.9	0.6	1.6
1985	0.8	0.9	1.7
1986	0.7	0.3	1.0
1987	0.6	0.5	1.1
1988	0.5	0.9	1.4
1989	0.4	0.9	1.3
1990	NA	NA	NA
1991	NA	NA	NA

* Capture catches and pond harvests
** Totals may not agree due to rounding
Source: FAO Yearbook of Fishery Statistics, 1989

Appendix D.--Nicaragua. Cultured shrimp harvests, 1980-90

Year	Harvest*	Area**	
		Enclosures	Ponds
	Metric tons	Hectares	
1980	-	NA	-
1981	-	NA	-
1982	-	NA	-
1983	10	NA	-
1984	NA	NA	-
1985	NA	NA	-
1986	NA	NA	-
1987	28♦	129	-
1988	70	400	-
1989	140E	600	NA
1990	200E	1,000	90
1991	NA	NA	NA

* FAO indicates that the catch is primarily <u>P. vannamei</u>. INPESCA reports that harvests are mostly <u>P. stylirostris</u> and <u>P. occidentalis</u>.
** Mostly estuarine enclosures and not ponds.
♦ FAO reports 45 tons.
E - Estimate
Sources: FAO. "Aquaculture Production" various years, <u>FAO Fisheries Circular</u>, No. 815; U.S. Embassy, May 20, 1987; and INPESCA. "Perspectivas de la Camaronicultura en Nicaragua," unpublished report, 1990.

Appendix E.--Nicaragua. Wild and cultured shrimp harvests, 1980-90

Year	Production		Total	Proportion cultured
	Wild	Cultured		
	1,000 Metric tons			Percent
1980	4.1	-	4.1	-
1981	3.5	-	3.5	-
1982	2.7	-	2.7	-
1983	1.5	Negl	1.5	-
1984	1.6	NA*	1.6	-
1985	1.7	NA*	1.7	-
1986	1.0	NA*	1.0	-
1987	1.1	Negl	1.1	-
1988	1.4	0.1	1.5	7
1989	1.3	0.1	1.4	7
1990	NA	0.2	NA	NA
1991	NA	NA	NA	NA

NA - Not available
* Presumably negligible
Sources: Appendices C and D.

Appendix F.--World. Shrimp imports from Nicaragua, 1980-90

Year	Country			Total
	U.S.	E.C	Japan	
	1,000 Metric tons			
1980	2.6	-	-	2.6
1981	1.7	-	-	1.7
1982	1.3	-	-	1.3
1983	0.8	-	-	0.8
1984	0.5	-	-	0.5
1985	0.3	0.1	-	0.4
1986	-	0.1	-	0.1
1987	-	-	-	-
1988	-	0.1	-	0.1
1989	-	Negl	-	Negl
1990	0.3	0.1	-	0.4
1991	0.5	NA	-	NA

Note: The U.S., EC, and Japan account for the bulk of the shrimp imported by most countries. Small quantities could be shipped to other countries. In the case of Nicaragua, some shrimp may have been shipped through other countries after 1985 to evade the U.S. embargo.
NA - Not available
P - Projection based on data available through November.
Sources: U.S. Bureau of the Census, EC NIMEXE, and the Japan Tariff Association.

Appendix G.--United States. Shrimp imports from Nicaragua, 1980-90.

Year	Imports	
	Quantity	Value
	1,000 Metric tons*	US$ Million
1980	2.6	20.8
1981	1.7	12.5
1982	1.3	9.2
1983	0.8	6.4
1984	0.5	4.6
1985	0.3	2.8
1986	-	-
1987	-	-
1988	-	-
1989	-	-
1990	0.4	2.3
1991	0.5	3.4

* Product weight (mostly tails)
Note: Unconfirmed reports suggest that some shrimp was exported to the United States surreptitiously to avoid the U.S. trade embargo (1985-90) by shipping it through third countries (Guatemala, Honduras, Panama, and others).
Source: U.S. Bureau of the Census.

3.8

PANAMA

Panama was one of the earliest countries in Latin America to establish a commercial shrimp culture industry. A U.S. company founded Agromarina, Panama's first shrimp farm, in the early 1970s and achieved successful results. A variety of environmental conditions in Panama offer generally favorable, but not ideal, conditions for culturing shrimp. Those conditions include: a stable tropical **climate**, unused **saltwater marshes** bordered by mangroves, adequate **soil**, good **water** characteristics, and the availability of two indigenous marine **species** which perform well in ponds--*Penaeus vannamei* and *P. stylirostris*. Some observers note, however, that Panamanian growers report lower annual yields than growers in several other Central and South American countries. The reasons for these lower yields are not fully understood. Many point to Panama's dry summer season (December/January-May) which poses some difficult pond management problems to shrimp growers. Other climatic factors and farm management practices also appear to be involved.

Agromarina's success has been repeated by only a few of the growers which subsequently attempted to farm shrimp in Panama. As a result, the industry has expanded only slowly. Many growers have lost money or reported only marginally profitable results. Observers offer a variety of reasons for the industry's lack of success. Some growers began farming with no academic preparation or practical experience in aquaculture and generally underestimated the technical difficulty of culturing shrimp. Many early growers gave inadequate attention to site selection and farm design. Small-scale growers did not build sufficient ponds to create viable economic units. Other problems which have hindered the industry's growth include poor commercial feeds, high fuel and electricity rates, and various Government policies. The industry's problems were compounded in the early 1980s by the regional debt crisis and in the late 1980s by the economic and political instability resulting from Noriega Government policies and U.S.-imposed sanctions. Few investors were willing to commit funds in the chaotic Panamanian economy.

The authors have received widely varying reports concerning the results being achieved by Panamanian growers and, as a result, it is difficult to assess the current situation. Panamanian harvests appear to have remained fairly low, totaling about 3,500 metric tons in 1989--only a marginal increase over 1986 levels. Some local observers at the beginning of 1991 projected significantly improved growout results for the year. Despite these optimistic projections, the 1991 harvest may have declined to as low as 2,500 tons. Some observers, however, provide substantially higher estimates. Actual 1990-91 results are unclear at this point because the authors have received such widely varied estimates on pond harvests. Despite the sharply divergent estimates, most observers agree that actual 1991 results were less than had been anticipated. Farmers reported that both disease problems and insufficient rainfall which impaired operations. The poor 1991 results are especially troubling because some observers were optimistic that the demise of the chaotic Noriega regime would create conditions permitting a rapid expansion of the industry. This has clearly not occurred. The current situation, however, in Panama exhibits a variety of conflicting trends. An increasing number of growers are gaining experience and substantial numbers of technicians have completed specialized training. New farms and pond additions at existing farms are much better designed than the early farms. Several small, uneconomic farms have closed and newer projects are generally larger, more viable units. Despite these favorable developments, problems persist. Even some of the more advanced farms (Agromarina) reported disappointing yields in 1991, although at least one large farm (Aquachame) reported more favorable results.

The country could report substantial harvest increases during the 1990s, if the industry addresses some of its major problems. Most observers report a sizeable area of potential sites are available in Panama for additional pond construction. Some optimistic observers believe that a harvest of 10,000 tons is theoretically possible by the year 2000. The country's full potential may be even larger, but the industry's ability to reach that potential in the next few years is questionable. The difficulties experienced by Panamanian growers to date are not encouraging. The persisting problems suggest some caution should be used in assessing the more optimistic projections of Panamanian industry groups. Even if some of the administrative and economic problems are addressed, Panamanian growing conditions do not appear to be as favorable as in some other Latin American countries. As a result, actual harvests by 2000 may be substantially below the more optimistic projections. A conservative projection of about 5,000 tons seems a reasonable estimate for 2000.

Panama's successful hatcheries are playing an increasingly important role in the Latin American shrimp culture industry. Throughout the 1980s, shrimp growers in most Latin American countries were adversely affected by periodic shortages of postlarval seedstock. The increasing production of seedstock in Panama is now allowing growout operations to expand in countries with limited wild seedstock and begin even where no local seedstock is available. Most Panamanian hatcheries are associated with growout operations. Seedstock production is primarily used to supply associated domestic farms and for export sale. The profitable hatchery operations have become an important adjunct to growout operations, some of which have proven much less lucrative than the hatcheries. Some observers believe that Panama is emerging as a regional center for postlarvae production, an activity which could eventually eclipse shrimp growout in importance. Some Panamanian hatcheries may face financial difficulties, however, if the 1991-92 El Niño event results in substantially improved availability of wild postlarvae. Some Panamanian hatcheries reported significant marketing problems in 1991 and the situation may worsen in 1992 if the El Niño event intensifies.

CONTENTS

I. CAPTURE FISHERY

The Panamanian shrimp fishery is the largest in Central America. The fishery plays an important role in the local economy and is a major source of foreign exchange earnings. Panamanian fishermen have, however, been reporting declining catches in recent years. Even so, the capture fishery still dominates the country's shrimp industry and produces over 70 percent of the overall shrimp harvest (appendices D1-2).

Panamanian fishermen conduct both commercial and artisanal fisheries.

Commercial: Panama initiated a commercial shrimp trawl fishery in the 1940s. Good catches and favorable prices in the United States permitted a rapid expansion of the trawler fleet. Panama's shrimp fleet has been relatively stable in recent years at about 280 active trawlers, although industry and Government sources vary as to the exact number.[1] Almost all of the Panamanian trawlers are deployed along the Pacific coast, mostly out of Vacamonte--a Government-operated port located about 25 kilometers (km) from Panama City. Only a few trawlers (perhaps 2-3) are normally deployed in the Caribbean.[2] Pacific catch rates usually determine Caribbean deployment. If Pacific catches are good, few fishermen desire to fish in the Caribbean. Poor Pacific-coast catches, however, may force a few masters to attempt Caribbean operations.

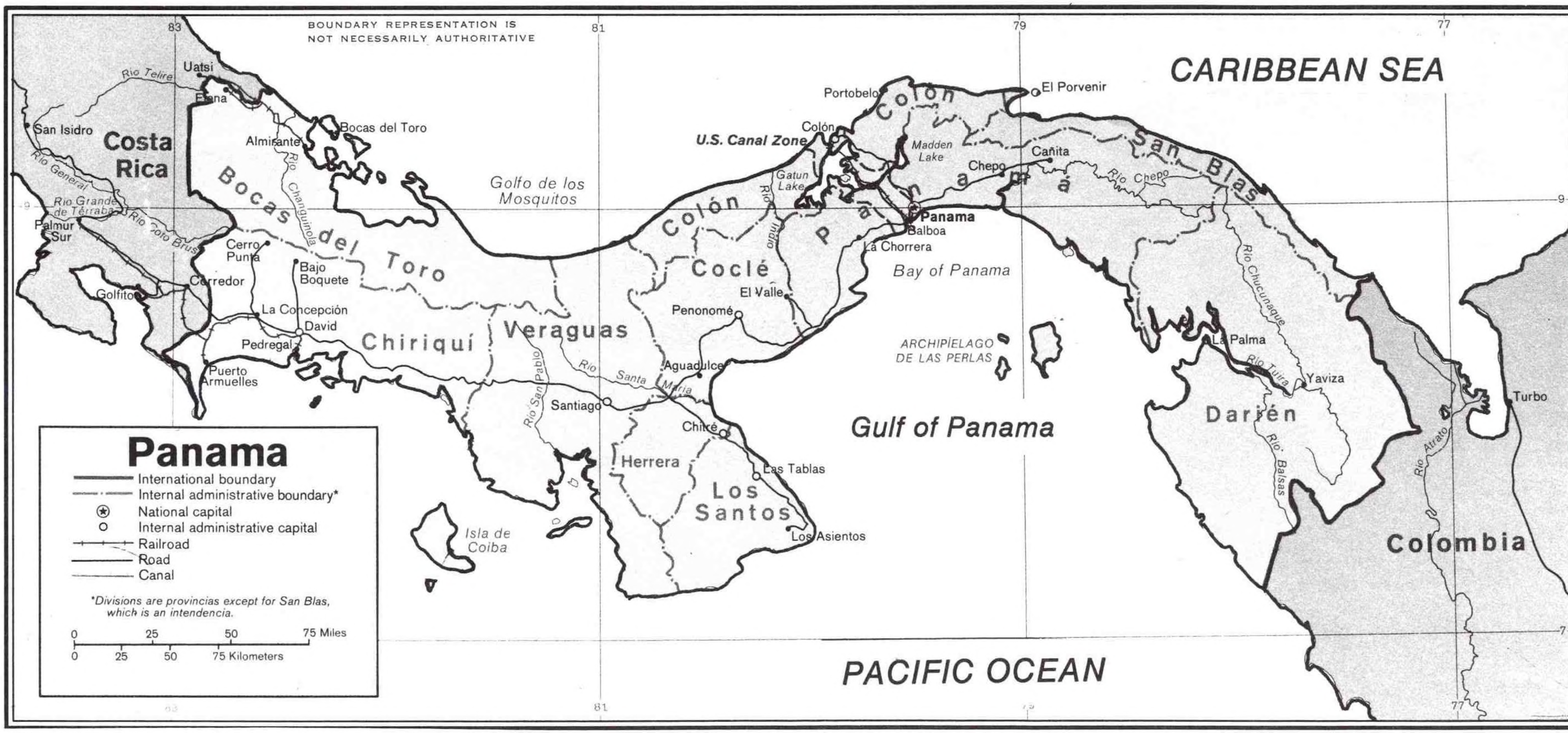
<u>Pacific</u>: Panamanian shrimp fishermen operate almost exclusively along the Pacific coast. The principal fishing ground is off the coast of Panama and Darien Provinces in the Gulf of Panama (map).[3] A smaller fishery is conducted in the Gulf of Chiriquí off Chiriquí Province.

<u>Caribbean</u>: Government officials estimate that only about 5 percent of Panama's trawlable shrimp grounds are located along the Caribbean coast, primarily because the shelf is very narrow. In addition, Caribbean fishing is hampered by coral reefs and seasonally rough weather.[4]

There are six major shrimp companies in Panama which operate about 185 trawlers; the remaining trawlers are owner operated.[5] Catches peak from April through July. Trips last 7-24 days and average about 14 days. Masters operate their trawlers both during the day and night, but daytime fishing is most prevalent. The Panamanian fishery has been known for the larger-sized *Penaeid* shrimp which the fishermen target.[6] The fishermen in some years, however, land substantial quantities of less valuable smaller shrimp. (See: "VI. Species.") One observer suggests that the character of the fishery has been changing in recent years from one focusing on the high-value *Penaeids* to lower value, small species.[7]

Artisanal: Artisanal fishermen also catch shrimp, attracted by the high prices. While the fishermen use only small craft, their combined impact constitutes a substantial effort on juvenile shrimp. One estimate suggested that over 3,000 artisanal boats fishing shrimp and other species were deployed in Pacific estuaries. They fish the estuaries and other inshore waters which are the only grounds which they can easily reach in their small craft.[8] The artisanal fishermen report especially good catches at Albina las Palmas and la Albina el Tigre. In some cases, a single individual owned up to 20 boats, somewhat blurring the distinction between artisanal and commercial fishing. The Government currently limits individual fishermen to a maximum of four boats.[9] Many artisanal fishermen are now deploying gillnets. Artisanal catches, as reported in official statistics, comprise only a small part of the country's shrimp catch (appendix D5). Data on artisanal fisheries are difficult to gather, however, and available official statistics may be unrealistically low.

Panamanian shrimp fishermen have reported a substantial catch decline since the mid-1980s (appendices D1-6 and figure 1). Catches and pond harvests have varied from a high of 15,900 metric tons (t) in 1985 to a low of only 6,000 t in 1988 (appendix D3). The sharp 1988 decline resulted in a crisis affecting all sectors of the industry except the farmers.[10] It is difficult to assess industry trends, however, because considerable discrepancies exist between available shrimp catch data sets (appendices D1-6). Despite the absolute discrepancies, all reports confirm that shrimp catches dropped sharply from 1985-88 (appendix D1-6). The 1989 catch improved somewhat (appendices D1-5), but Panamanian sources reported another poor catch in 1990.[11] The total 1990 wild catch fell sharply (appendix D2 and D5).[12] The 1990 white shrimp catch barely exceeded 1,000 t, a decrease of almost 20 percent compared with 1989 and almost 16 percent less than the average for the last 5 years. Preliminary data (through May) suggest an improved 1991 catch. One observer noted that 1991 catches through May were up nearly 30 percent, but most of the increase was "titi" and other small, less valuable shrimp.[13] Another report later in



Map 1.--Map of Panama showing provincial boundaries.

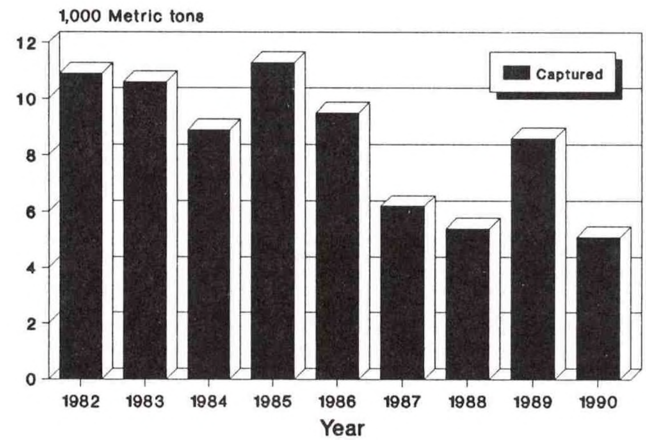


Figure 1.--Panama. Wild catches peaked in 1985 and have since declined.

the year also suggested that there would probably be a small increase in the wild catch for 1991.[14]

Observers attribute the declining wild shrimp catch to a variety of factors. Many believe that stocks have been overfished.[15] The Dirección General de Recursos Marinos (DIGEREMA)[16] estimates that the trawler fleet should be reduced to only about 230 vessels.[17] DIGEREMA Director Roy Cardoze believes that as many as twice the recommended number of trawlers may be operating in Panama.[18]

Most industry groups agree that the commercial trawl fleet needs to be reduced. Individual companies do not appear ready, however, to take the first step and reduce their own fleets.[19] Officials believe as many as 15 trawlers may be retired from the fishery in 1992 because of age and financial problems.[20] The Government is studying the possibility of refitting trawlers for alternative fisheries.[21]

Other factors besides excess fleet capacity are probably impairing stocks. Some observers point to fine mesh nets which result in a large catch of juveniles.[22] Government officials are concerned with the artisanal shrimp catch because much of it is juveniles taken before the shrimp move off shore to mature. Officials worry about the expanding use of gillnets by artisanal fishermen.[23] The Government has only a limited enforcement capability and finds it virtually impossible to significantly reduce the use of fine mesh nets by artisanal fishermen in the country's extensive estuarine system. Other observers point to climatic factors. Normal seasonal fluctuations or even El Niño cycles can significantly affect stocks.[24]

Panama's shrimp industry is reporting serious economic problems as a result of the declining catches. Some observers describe the situation as a crisis. However it is described, the result has been sharply lower earnings for fishermen, processors, and exporters. Various observers have reported the deteriorating financial condition of the industry.[25] The decline in export earnings since 1986 has been especially dramatic. Most of the shrimp catch is exported to the United States. Shipments in 1986 peaked at nearly $80 million, a significant contribution to the small Panamanian economy. These exports earnings have since declined abruptly, nearly 50 percent since 1986 (appendix K4).[26] (See: "XIII. Markets: Exports.") This precipitous decline has drastically affected company profits. Companies were also faced with problems associated with the political and economic turmoil in Panama.[27] This turmoil, combined with the declining catches and profits, has created very serious difficulties. As a result, many companies as well as individual fishermen report financial trouble. Several shrimp processing plants have begun to process other products.[28] Industry groups have complained that the shrimp industry during 1990 was not benefitting from the improving economic conditions in the country following the arrest of General Noriega.[29] (See: "IV Economic Conditions.") Industry groups have continued to report serious economic problems throughout 1991 as a result of the depressed catch levels.[30]

The Government is attempting to reverse the catch declines through a variety of management measures. DIGEREMA has for years restricted the number of trawlers to limit effort as recommended by the agency's biologists.[31] General Noriega personally authorized, however, the issuance of new licenses, invalidating DIGEREMA's management efforts. DIGEREMA enforces an annual closed season to protect spawners. The seasonal closure has traditionally been 2 months, but was increased to 3 months in 1990 (February-April).[32] The Government announced new shrimp regulations in November 1990 to improve the management regime.[33] The management program was revised again in 1991. The Government decided to go back to a 2-month closed season, but to restrict fishing effort during part of the open season.[34] The commercial fishermen have often criticized the government's attempts to limit fishing effort. The Sindicato de Marinos Pesqueros (SMP), for example, opposed an additional closed season which the Government was reportedly considering in 1988.[35]

II. AQUACULTURE INDUSTRY

Panama would seem to be a suitable location for one of Latin America's small, but relatively important aquaculture industries. The country's name in the indigenous language is "land of plentiful fish." Panama has had more experience with aquaculture than many other small Latin American countries which are attempting to culture shrimp. Panamanian groups have been working with aquaculture for several years. The first aquaculture project was initiated in 1925 to introduce rainbow trout. More recently the industry has focused on low-value species which could be easily cultured by small-scale farmers to increase the availability of food in rural communities.

The Panamanian Government has shown considerable interest in aquaculture. The Government built the Divisa Center in 1972 at Santa María, Herrera Province. (See: "XVIII. Technical Capability.") The Panamanian Government initiated a formal fish culture program in 1976, creating the Dirección Nacional de Acuicultura (DINAAC).[36] The program received high-level backing from Panamanian officials. Then President Torrijos himself insisted that he would "not rest until there was a fish pond in every village." The Government's efforts to promote the aquaculture industry were assisted by the U.S. Agency for International Development (AID) which in 1980 helped to set up a pilot program. The Inter-American Development Bank (IDB) also provided financial assistance. The Government built demonstration ponds and produced tilapia and carp seedstock for growers at the Divisa Estación Experimental Dulce Acuícola (Freshwater Aquaculture Experimental Center). Panamanian fish farmers are currently working with various introduced species, including tilapia, carp, lobina, mojarra, and freshwater shrimp. Harvests, however, are small. Growers harvested barely 700 t of finfish in 1988 and that may have declined to only 200 t in 1989.[37]

DINAAC has primarily focused on freshwater programs, but has also done some work on mariculture as well. DINAAC participated along with Agromarina in shrimp culture research beginning in 1974. The agency currently administers three research centers which do at least some work on mariculture growout and/or hatcheries: 1) the Estación Experimental de Aguas Estuarinas/Salobres Ing. Enrique de Enseñat (EEAS), 2) Estación de Maricultura del Pacífico, and 3) the Laboratorio Larvario de Carrasquilla. (See: "XVIII. Technical Capability.")

III. GROWING CONDITIONS

Panama is a small, extremely narrow country. Its elongated dimensions are laid out roughly in the shape of a sideways letter "s". At its narrowest point (near the Canal), Panama is only about 48-km wide. Despite the country's small area, a substantial number of potential sites exist that could be developed by growers. The country also offers some favorable physical conditions for shrimp growers, especially the tropical climate and extensive coastal area. Some observers believe, however, that climatic conditions

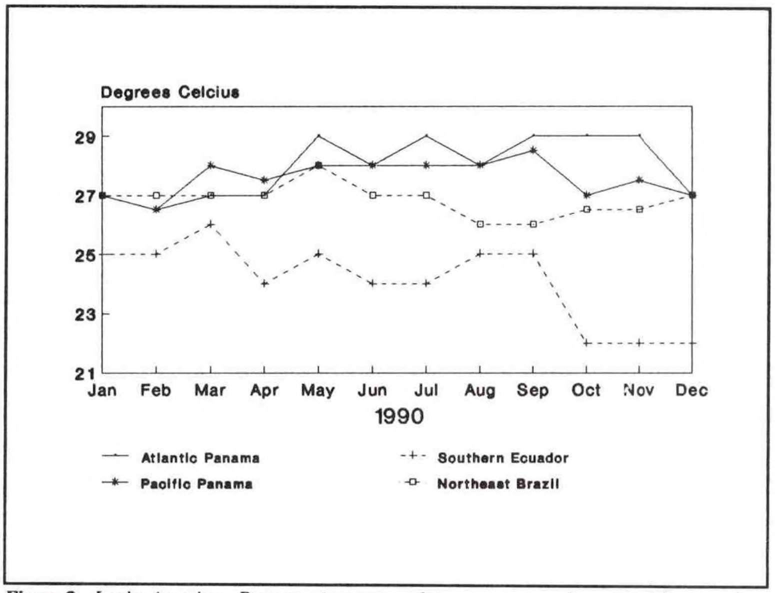


***Figure 2**.--Latin America. Panama has some of the warmest and most stable seasurface temperatures in Latin America.*

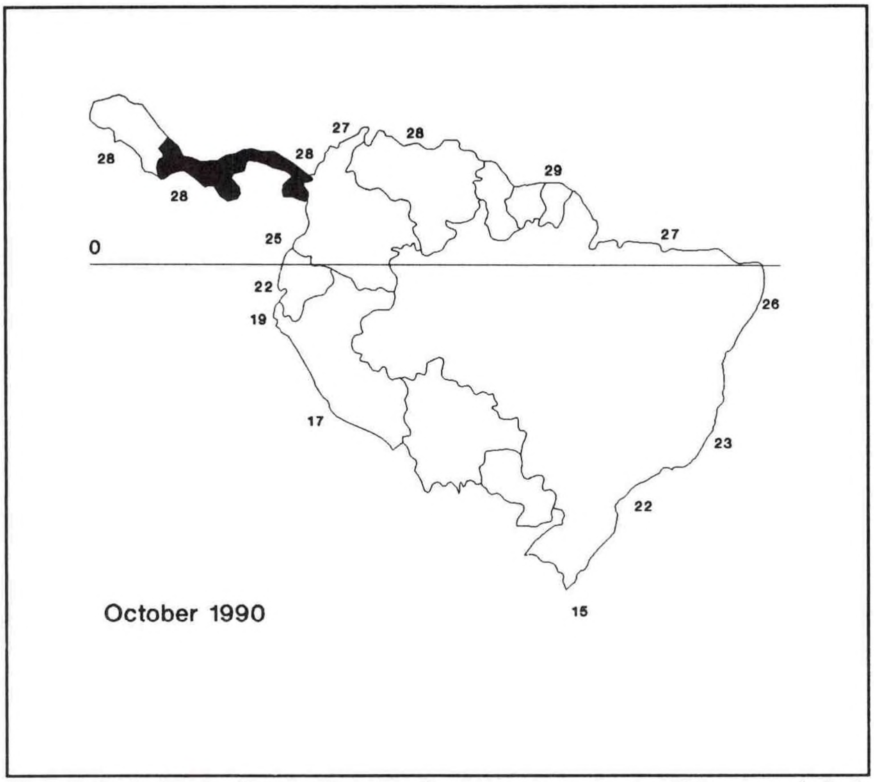


Figure 3.--Latin America. Panamanian sea surface temperatures are some of the warmest in Latin America.

the largest shrimp fishery in Central America.

Caribbean: The shorter Caribbean coast of about 1,200 km has a much narrower shelf area and limited mangrove estuarine habitat. As a result, the Caribbean coast supports a significantly smaller shrimp population than along the Pacific coast.

Freshwater: Panama benefits from abundant supplies of freshwater. Annual precipitation levels are high, varying from 1.7 meters (m) along the Pacific (Panama City) to 3.2 m along the Caribbean coast (Colon). The country has more than 550 rivers and streams. Water availability, however, is highly seasonal. Precipitation is abundant during the rainy season (May to December), but growers report difficulty obtaining adequate volumes during the annual Pacific dry season (December/January to May). (See: "VII. Methods.") One study noted rain on only two occasions during the 1984 dry season.[40] The shortage of freshwater during the dry season, combined with other factors, adversely affects yields. (See: "VIII. Yields/Production Costs.") The Caribbean dry season is shorter, but this is of no benefit to the shrimp growers, all of whom are currently located along the Pacific coast.

are not optimal in Panama and that several other countries offer superior growing conditions. The dry season, which can be severe in some years, appears to impair operations at many farms.

Climate: Panama has a relatively stable, tropical climate. Sea surface temperatures off Panama are some of the warmest and most stable available anywhere in Latin America (appendix C and figure 2 and 3). One observer reports, however, that strong prevailing winds ("viento del norte") during the summer dry season may cause considerable evaporative cooling, reducing pond temperatures.[38]

Coastal area: Panama in relation to its size has an impressive extension of coastline. The country has one of the highest ratios of coastline to land mass in Latin America.

Pacific: The Pacific coast of about 1,600 km is notable for habitat diversity. It has extensive shelf area, primarily in the Gulf of Panama and, to a lesser extent, in the Gulf of Chiriquí (map). A large number of islands occur along the coast. Suitable mud-flat estuaries, many with mangrove forestry, serve as nursery areas providing ideal habit for juvenile shrimp.[39] The extensive shelf area provides offshore habitat for adult shrimp. The combination of estuaries and shelf support

Photoperiod: The number of hours of sunlight appears highly favorable.[41]

Productivity: Some data exists on phytoplankton, primary productivity, and zooplankton. Marked differences exists between the rainy and dry seasons.[42]

Salinity: Salinity in Pacific coast estuaries generally varies from 15-40 parts per thousand (ppt), fluctuating primarily due to seasonal precipitation patterns. Salinities are particularly high during the dry season.[43]

Tidal range: Some Pacific-coast areas experience exceptionally large tidal ranges, averaging about 4 meters.[44] One observer reported Pacific-coast tides of up to 6 meters.[45] Tides along the Caribbean coast are much more moderate, averaging less than 1 meter.

Water quality: While Panama has significant water resources, some observers have expressed concern with water quality. One expert notes the expanding agricultural development in Panama and the intensive use of agricultural chemicals (fertilizer and insecticide).[46] Only limited data, however, is available to the authors on water quality.[47] Water quality could prove to be a specially serious problem in Panama as most of the farms are currently tightly clustered in a relatively few locations. Reports already suggest that pond effluent is generally released in a manner that contaminates the intake water used by other farms.[48]

Other factors: More information is available on Panamanian conditions than on many other countries in the region as a result of the Collaborative Research Support Program (CRSP) study financed by the U.S. Agency for International Development (AID).[49]

IV. ECONOMIC CONDITIONS

A variety of economic factors has affected the development of Panama's shrimp culture industry. Panamanian growers enjoy several economic advantages, although they also face some difficult problems.

Credit: Panama is an international banking center, somewhat easing the problem of obtaining investment capital. Even so, growers have reported considerable difficulty financing projects because of the regional debt crisis. Other Latin American countries with shrimp culture industries (Brazil, Ecuador, Mexico, and Peru) have also been seriously affected by the debt crisis. In Panama the situation was exacerbated in the late 1980s by the increasingly chaotic Noriega regime and U.S.-imposed sanctions. (See: "XVII. Credit.")

Currency: Panamanian growers have an advantage over other Latin American growers because the U.S. dollar is the country's official currency. As a matter of form, the U.S. dollar is referred to locally as the Balboa. The use of U.S. currency avoids the currency exchange and control problems as well as the run-away inflation that growers have faced, and continues to face, in several other countries.[50]

Electricity/fuel rates: Some industry sources report that fuel and electricity rates are higher than in many other countries that are culturing shrimp. At least one local observer speculates that this has been a major factor impeding the industry's development.

Infrastructure: Panama has a relatively developed infrastructure, especially along the Pacific coast. That infrastructure, however, has suffered from years of neglect and is in need of considerable investment for maintenance and repair. Electrical power and water supply can be problematical during the dry season.[51] Even so, current growers benefit from the fairly well-developed infrastructure available in Coclé Province and other areas where the existing ponds are located. Not only do the growers have access to adequate roads, but the existence of the Canal has helped Panama develop into a regional transportation hub. Growers can easily ship to their traditional U.S. market and with more difficulty to the new markets which they are developing in Europe. (See: "XIII. Markets: Exports.") Future growers who desire to develop new areas (Boca del Toro and Darien), however, may encounter much more difficult infrastructure/transportation problems in those lightly populated areas. Both construction and operating costs may prove much higher than in the already developed areas of Coclé and other provinces (appendices H1-2).

Investment code: Panamanian investment regulations are favorable to foreign investors. The country makes almost no differentiation between Panamanian and foreign nationals. (See: "XVII. Credit.")

Labor costs: Panamanian workers enjoy some of the highest wages in Latin America. As a result, labor costs in Panama will tend to exceed those in most other Latin American countries.

Shrimp processing industry: Panama has an established shrimp processing industry. Processors have shipped to the United States for years and have demonstrated the ability to meet the high quality standards required in the international market. (See: "XII. Processing.")

The Panamanian economy at the beginning of 1990 was in a shambles after 2 decades of poor economic policies, the chaotic Noriega regime, and U.S. economic sanctions. President Endara's new democratically elected civilian Government inherited numerous problems from the Noriega regime: large arrears with the International Monetary Fund, the World Bank, and the Inter-American Development Bank; substantial unemployment; and a deteriorating network of public sector services (electricity, water, roads, and ports). In addition, civil disturbances and looting following the December 20, 1989, U.S. military action resulted in substantial damage to private businesses.

The new civilian Government is attempting to restore confidence and has reported some success. The economy is showing signs of recovery from the economic downturn experienced during 1988-89, the last 2 years of the Noriega regime. The 1990 gross domestic product (GDP) totaled $4.8 billion and grew about 3.4 percent.[52] Improvements were reported in virtually all economic sectors during 1990. Several economic indicators have turned positive, including construction permits, electricity usage, and trade data. The Government is preparing an economic reform program in cooperation with international financial institutions and is launching various public sector investments to improve the country's deteriorating infrastructure. The Government's primary focus is to encourage private sector investment. Projections for real 1991 GDP growth varied from 3.5-5.0 percent.[53]

V. AREA/LOCATION

A. Potential

The total potential area of sites which could be developed for pond construction in Panama is not known with any precision. Various observers have estimated the area but none appears to be based on a detailed coastal survey. Most estimates suggest, however, that growers have a substantial area of undeveloped sites available for farm development. One observer cautions that some of these estimates may include marginal sites and thus should be taken with considerable caution.[54]

Pacific coast: Panama's shrimp culture industry has developed along the Pacific coast, at least partially because of the more developed infrastructure and availability of wild postlarval seedstock. Estimates vary on the potential pond area. One observer estimates that only around 7,500 hectares (ha) are suitable for ponds along the Pacific coast.[55] Another estimate suggests that about 9,000 ha of ponds could be built, presumably along the Pacific.[56] Yet another source reported potential sites could total as much as 12,000 hectares.[57]

Caribbean coast: Little information is available on the potential along the lightly populated Caribbean coast. One observer notes that development of Caribbean coast sites has been impeded not only by the lack of roads and other infrastructure, but also because the terrain in many areas is less suitable than along the Pacific. The Caribbean coast is much more rugged, with less flat coastal land and only a fraction of the mangrove forestry which occurs along the Pacific. As a result the area of suitable sites may prove extremely limited.[58]

The primary area for pond construction is Coclé Province. Another area for development is the salt marshes/flats ("albinas"), especially in the Azuero Peninsula (map). (The Azuero Peninsula is divided among three Provinces: Veraguas, Herrera, and Los Santos.) One observer estimated that the area of salt flats is concentrated in Herrera (3,800 ha) and Los Santos (1,700 ha), but small areas also exist in Coclé and Chiriquí (map).[59] Other possible Pacific-coast sites for pond construction include the underdeveloped Darien area which has extensive areas of low-lying swampy land. Some coastal agricultural land in the more western Chiriquí Province might also be suitable. Eventually some Caribbean coast sites in Colon and Bocas del Toro may be developed.[60]

B. Development

Growers are using both land which they have purchased outright and Government land for which they obtained concessions. The Government has offered 10-20 year concessions on about 10,000 ha of land, primarily salt flats.[61]

Panamanian shrimp farms are all located along the Pacific coast, primarily in **Coclé Province**, which accounts for over half of the country's total pond area (appendix H1-2). Extensive salt flats along the Gulf of Parita are located in Coclé. Almost all of the larger farms (Agromarina, Camaronera de Coclé, Panlangosta, Grupo de Salineros, La Gallinaza, and Hacienda el Rosario) are located in Coclé Province. (See map for the location of each Province.) Farms are also located in three other provinces.[62] The large Acuachame farm, for example, is located in **Panama Province**. Some observers report excellent sites in the mangrove areas near Punta Chame. Only a few relatively small farms are located in **Herrera** and **Los Santos Provinces**. Most Panamanian farms are clustered in a small number of centers. About 1,000 ha of those ponds are located on salt flats. Two major areas where farms are clustered are the low mangrove areas near Punta Chame and the salt flats edging the Gulf of Parita (map).[63] Growers have selected many sites on salt flats. One observer reports that unlike other Latin American countries, Panamanian growers have had only a marginal impact on the country's extensive area of mangrove forestry.[64]

Growers are expanding pond area. They have increased the area of ponds from 2,500 ha in 1985 to 3,700 ha in 1989.[65] Expansion has averaged about 300 ha per year since 1985. This is a fairly small area, but given the size of the Panamanian industry, not insignificant. The growth of pond area, since 1985, has been relatively steady, with the exception of 1987 when growers closed farms with about 200 ha of ponds. A substantial number of new ponds were built in 1988, but less than 200 ha in 1989. The failure to expand more rapidly appears to have been due to the poor results which many growers achieved and the growing economic disruptions associated with the Noriega regime and U.S. sanctions. Detailed pond area data for 1990 is not available, but probably totaled about 3,000 hectares. Some observers, however, suggest a somewhat larger area. A FAO study, for example, estimates about 3,200 ha of ponds had been built by the end of 1990.[66] Observers differ somewhat on the current area of ponds. Detailed pond area estimates broken down by farms suggest an area in early 1991 ranging from 3,300-3,800 ha (appendices H1-2).[67] More recent data suggests that as many as 4,200 ha of ponds were operated in 1991, although some estimates suggest as much as 4,500 ha of ponds (appendix E1 and figure 4).[68]

The fall of the Noriega Government in 1989 seems to have had a significant favorable impact on Panama's struggling economy. (See: "IV. Economic Conditions"). The impact on the shrimp culture industry, however, is not yet clear. Some expansion of pond area appears to have occurred in 1990 and 1991 after General Noriega's arrest. Unconfirmed reports suggest that growers are now conducting several major expansion programs which will significantly increase pond area. The largest company, **Agromarina**, plans to nearly double its pond area from 625 ha to 1,125 hectares. A U.S.-Panamanian joint venture, **Pacumar**, plans to build a large new farm.[69] Several existing farms are reportedly planing to increase pond area.[70] Details, however, are not available on these expansion programs. Some observers continue to express caution over the industry's future. One industry spokesman insists that there has been no significant upsurge of new investments.[71] Another observer reports in 1991 that many farms reported difficulties and disappointing harvests.[72] At least one large farm (Aquachame), however, appears to have had a successful year.

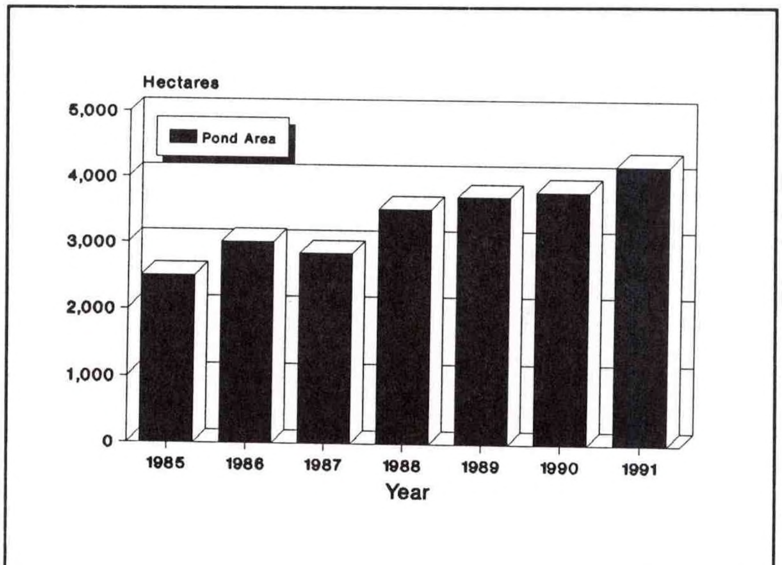


Figure 4.--Panama. Growers are steadily expanding pond area.

VI. SPECIES

The Panamanian capture shrimp fishery is based on a variety of species. The principal *Penaeids* are Pacific pink shrimp (*Penaeus brevirostris*), Pacific brown shrimp (*P. californiensis*) and three species of Pacific white shrimp (*P. occidentalis, P. stylirostris,* and *P. vannamei*) (appendix B).[73] Fishermen also take substantial, but highly variable quantities of lower-valued Pacific seabobs (*Xiphopenaeus kroyeri riveti*) and other small species (such as *Trachypenaeus byrdi*). The catch of these species is highly variable over time (appendices D3-4). Some reports suggest that the principal species is pink shrimp (*P. brevirostris*) with annual catches of up to 4,300 t, although white shrimp catches taken as a group exceed pink catches (appendix D3). Other sources report smaller pink shrimp catches (appendix D4). Non-*Panaeid* shrimp catches are highly variable, but in some years have totaled up to 7,000 t, or nearly half the overall shrimp catch (appendix D3). Current reports suggest that catches of these smaller non-*Penaeid* species in recent years have been comprising an increasingly important share of the overall shrimp catch. One observer reports in 1991, for example, that shrimp trawlers were averaging catches consisting of about 1.9 t, composed of more than 80 percent small shrimp (mostly "Fidel" and "titi" shrimp) and less than 20 percent white shrimp (mostly *P. vannamei* and *P. stylirostris*).[74]

Panamanian growers are culturing primarily marine species, but a few small growers are also experimenting with freshwater shrimp.

A. Marine

Panamanian growers culture *Penaeid* white shrimp. The availability of wild white shrimp pl which can be used to stock ponds has proven a great advantage to Panamanian growers. Two of the three species of white shrimp which occur off Panama's Pacific coast (*P. vannamei* and *P. stylirostris*) have proven suitable for pond culture (appendix B).[75]

Agromarina, other farms, and government researchers have conducted extensive experimental and commercial runs with both suitable white shrimp species. While much of the data compiled by companies has not been released for publication, employees leaving Agromarina have helped to spread the company's findings to other companies.

Penaeus vannamei: Most Panamanian growers prefer to stock *P. vannamei*, the species also favored by other Latin American shrimp growers. Researchers have generally found that the best yields and survival rates are obtained with *P. vannamei*.[76] Obtaining *P. vannamei* pl, however, is complicated by the fact that it is not the dominant species occurring off Panama. Detailed data on wild abundance is not available to the authors, but most observers confirm that *P. vannamei* is not the primary species.[77] During at least part of the year, especially during the dry season, *P. vannamei* pl can become extremely scarce. Many Panamanian growers report mixing *P. vannamei* and *P. stylirostris* pl (varying proportions) in their ponds.[78] Panamanian hatcheries have primarily concentrated on *P. vannamei*, but it has proven a relatively difficult species with which to work.

Penaeus stylirostris: Panamanian growers also culture substantial quantities of *P. stylirostris*. One source indicates that as much as 40 percent of the harvest may be *P. stylirostris* (appendix D6), a higher proportion than in any other Latin American country. It is not clear why Panamanian growers stock *P. stylirostris* more than other Latin American growers, but it may be due to the species' high abundance in the wild pl collected for postlarval seedstock. Many small growers continue to rely almost exclusively on wild postlarvae. In addition, some hatcheries produce *P. stylirostris* because it is easier to work with than *P. vannamei* and because the species is so widely used in Panama.

Penaeus occidentalis: *P. occidentalis* is not cultured due to its low growth and high pond mortality rates.

Substantial quantities of postlarval seedstock are collected in Panama, although abundance is subject to sharp fluctuations. The country's extensive mangrove estuarine system, abundant freshwater flows, and large shelf area offer ideal shrimp habitat. Marked fluctuations occur in both abundance and species distribution.

Seasons: Pl can be collected throughout the year, but there are sharp seasonal fluctuations. During the dry season (December/January to May), the proportion of wild-caught *P. vannamei* pl decreases relative to the share of *P. occidentalis*, and to a lesser extent *P. stylirostris*. The availability of *P. vannamei* pl can decline to quite small proportions.[79] The share of *P. stylirostris* pl can reach up to 90 percent during this period.[80] This leads to high quantities of *P. stylirostris* in the seedstock consignments collectors deliver to growers and probably explains the substantial use of the species. After the rainy season begins in April or May, the species composition begins to change. The share of *P. vannamei* pl available increases gradually from 20 to 60 percent.[81] At the height of the rainy season (especially October and November) *P. vannamei* is most abundant.[82]

Areas: DINAAC reports that there is a spatial relationship to pl occurrence. *P. occidentalis* pl is generally found in the higher salinity zones of the estuaries, while *P. stylirostris* is found in the medium and *P. vannamei* pl is found in the lower salinity zones.[83]

Annual: Some authors have noted annual declines in the proportion of *P. vannamei* postlarvae. The reason for such a decline is unknown, but the prevalence of *P. stylirostris* appears to have become increasingly pronounced after 1985. This may be another factor explaining the widespread use of *P. stylirostris* by Panamanian growers. Many farms have had to adjust pond management practices because most were accustomed to working with *P. vannamei*. One observer noted, for example, poor results with nursery pond transfers using practices developed for *P. vannamei*.[84]

B. Freshwater

Several species of freshwater shrimp occur in Panama (appendix B), but none have proven suitable for culture. Growers have turned to *Macrobrachium rosenbergii*, an exotic species used by most other Latin American growers.

VII. METHODS

Panamanian growers have experimented with both marine and freshwater culture. All important commercial farms, however, use the more easily marketable marine species.

A. Marine Shrimp

Panamanian shrimp farmers use both extensive and semi-intensive systems. The earliest growers attempted to introduce Ecuadorean-style extensive operations. Many of these projects, however, were ill-conceived. Investors had no experience with aquaculture and did not comprehend the technical demands. Many were unwilling to pay the fees needed to obtain technical assistance. Small growers in any case simply could not afford such services. Not surprisingly, most achieved very poor results. (See: "XI. Harvests.") Several growers, as a result, have gradually shifted operations and the more important growers now mostly use semi-intensive systems. Most small operations, however, continue to use extensive methods. One observer reports that semi-intensive farms accounted for about 75 percent of the total pond area in 1991 (appendix H2).

Extensive systems: Extensive farms, especially the smaller ones, are generally operated by individuals with limited economic resources. There are only a few large extensive farms: **Grupo de Salineros, la Gallinaza, Salinarios (Guararé), Aguilar, Camarón,** and **Cooperativa Che Paulito** (appendix H2). Many of these farms are situated on salt flats.[85] Some of the individuals who entered the shrimp culture industry, already owned salt evaporation ponds which they operated during the dry summer months. The possibility of culturing shrimp when the ponds were normally idled (during the winter rainy season) was appealing. Other investors have built ponds in salt marshes/flats, specifically designed to culture shrimp. Extensive farms required much smaller initial investments. The characteristics of these extensive farms vary widely. Ponds ranged anywhere from 2-50 hectares. Pond embankments were often constructed at minimal costs and, as a result, most cannot support vehicle traffic which greatly complicates pond management. Panama's annual dry season has a particularly serious impact on extensive farms and most are closed during this period.[86] The ponds are filled with the monthly "aguajes," beginning in May when the rainy season usually begins. A few growers use pumps to maintain water levels. Extensive growers rely on the pl naturally present in the water, but some may add additional pl in an effort to achieve stocking densities of about 2.5-3.5 pl per square meter (m^2). They also rely on the food naturally present in the water, but may supplement it by applying organic and inorganic fertilizer. Growers also add available material from various agricultural (such as coconuts or yuca waste products) or fishery (fish offal and shrimp heads) activities, depending on what is easily obtainable near the farm. A few growers apply minimal amounts of low-grade feed (20-25 percent protein). Many growers try to eliminate predators (fish and crabs) by periodically using nets. Some growers operate on a one-crop (7-month cycle) while others attempt two-crop (3.5-month cycle).

Semi-intensive systems: More sophisticated semi-intensive farms have been built by growers with greater financial resources. Some of the principal semi-intensive farms include: **Agromarina, Aquachame, Camaronera de Coclé, Hacienda el Rosario, Granjas Marinas,** and **Panlangosta** (appendix H2). Growers report construction costs of about $4,500-$5,000 per ha, including earth moving equipment, installing pumps, flow gates, etc. Pond depth varies from 0.8-1.0 meters. Farms have both nursery ponds (0.1-0.5 ha) and growout ponds (10-20 ha). Growers stock with both wild and hatchery postlarvae. (See: "XIV. Postlarvae Supplies.") Nursery ponds are stocked at densities of about 250 pl per m^2 for about 30-45 days. Growers report 60 percent survival rates to 1.0-1.5 gram (gm) juveniles. Large quantities of the unwanted shrimp species die during this period. Stocked pl may be only 20 percent preferred species (*P. vannamei* and *P. stylirostris*), but after the nursery phase is completed might be as high as 60 percent.[87] Stocking densities in growout ponds vary from 8-15 pl per m^2, depending on whether the pl are raised in nursery ponds or stocked directly in the growout ponds. Water exchange rates vary from 3-5 percent daily. Both fertilizers and balanced feeds (15-35 percent protein) are used. The ponds are designed so about 95 percent of the water can be gravity drained by opening outflow gates. The better farms are reportedly achieving nearly 3 harvests per year.[88]

Intensive systems: The authors know of no intensive farms in Panama. One observer reports, however, that given the limited area of suitable sites, potential Panamanian growers should consider possible intensive operations.[89]

Polyculture systems: Some shrimp growers are reportedly trying to supplement their earnings by culturing other species along with shrimp. One observer reports that shrimp are being cultured as part of a joint project with crabs and oysters. Two farms are attempting such systems. Agromarina is working with oysters and using them as feed. Las Guavas was working with crabs and oysters, but has discontinued the operation after reporting slow growth rates. The departure of the principal technician for Colombia made it difficult to continue the project.[90] Growers in other Latin American countries are also experimenting with polyculture systems. At least one Ecuadorean grower is known to culture oysters in shrimp ponds.[91] A Colombian grower is culturing tilapia in shrimp ponds.[92] Further details on Panamanian shrimp polyculture operations are not currently available.

Observers report various problems in Panama which affect yields.

Dry season: One of the most serious problems faced by Panamanian growers is operating during the long summer dry season (December/January to May) and growers have not been able to develop pond management systems to fully compensate.[93] Some attempts to compensate, such as increasing water exchange rates, have proven difficult to implement because of elevated salinities in available water. Growers have not yet determined precisely why yields fall during the dry season. Many believe that salinities are the principal problem, but trials by Agromarina assessing the results at various salinities (mixing freshwater and seawater), showed little variations in yields.[94] Some are convinced that a complicated interplay of salinities and pond temperatures reduce yields. The generally shallow depth of many ponds, for example, makes Panamanian growers particularly vulnerable to evaporative cooling from the strong north wind "viento del norte" which accompanies the dry season.

Feed: Many growers also complain of poor and inconsistent quality feed. A number of growers are convinced that poor quality feed is adversely affecting their yields.[95] Feed companies, however, dispute these charges and insist that they offer a quality product that will give acceptable yields. (See: "IX. Feed.")

Pond management: One observer reported in 1989 that overall yields were adversely affected by poor pond management practices. (See: "VIII. Yields/Production Costs.") Some of the common pond management errors noted by observers include: shallow pond water levels (often below 80 centimeters), low stocking densities (below 6 pl per m^2), use of pl only a few days old, and inadequate use of antibiotics. Panamanian growers are reportedly making some progress in improving methods and pond management, but the progress is difficult to assess because few growers release information on their operations.

Technical capability: Poor pond management is exacerbated by the limited technical capability at many farms and a general reluctance of many growers to share information.[96] One observer reports that some Panamanian growers seem particularly conservative and hesitant to implement needed technical improvements.[97]

B. Freshwater Shrimp

Panamanian freshwater shrimp growers use two different growout strategies.[98]

Continuous: Some farmers use the continuous harvest method which employs relatively high stocking densities (15-20 pl per m^2). They generally begin harvests after 5-7 months. Growers selectively harvest shrimp which have reached the desired size. These growers often add additional pl after the partial harvests.

Batch: Other growers use the batch ("lote") method in which the entire pond is harvested at one time. These growers first raise pl in a nursery pond at elevated densities (50-100 pl per m^2) for 30-45 days until they reach about 5.5 cm and 2.5 grams. The juveniles are then transferred to the growout ponds. Growers conduct monthly checks to determine density and weekly checks to assess growth rates. Depending on the results of these assessments, growers adjust feeding schedules and set optimal harvest dates.

Polyculture: Several researchers have evaluated possible culture with both indigenous finfish species and tilapia.[99]

VIII. YIELDS/PRODUCTION COSTS

Only limited data is currently available on the yields and production costs achieved by Panamanian growers. Most of the available data is provided by growers and cannot be independently confirmed.[100] Some observers are convinced, however, that production costs are relatively high in Panama compared to many other Latin American countries.

Marine shrimp: Available reports suggest annual yields varying from 0.1-1.8 metric tons (t) per hectare. One local observer in 1989 reported yields roughly confirming that range, estimating yields varying from 0.3-1.6 t per hectare. The wide range of yields results from the different methods used and variations in pond management. Some growers appear to be achieving improved results. One Government source reports yields of 0.5-0.7 t per harvest and about 2.5 harvests per year. This would mean an annual harvest of 1.3-1.8 tons.[101] Another observer confirms such yields, but suggests they were only being achieved at the more successful farms. He reports that growers were harvesting up to 2.5 crops per year and individual crops of 0.6 t per hectare. Agromarina is achieving nearly 3 harvests per year.[102] Yields are significantly impaired by the dry season and annual yields therefore cannot be simply calculated by extrapolating the high-yield harvest during the rainy season.[103]

> **Extensive farms**: Growers using the two-crop cycle reportedly achieve annual yields of 0.1-0.2 t per hectare. The harvested shrimp average 14-16 grams (gm).[104] Another observer estimates, however, that growers operating about 1,000 ha of ponds (presumably extensive farms), were reporting yields averaging only about of 0.5 t per ha (appendix F).[105]
>
> **Semi-intensive farms**: Growers report annual yields ranging from 1.1-1.7 t per hectare.[106]

The problems reported by many growers in 1990 and 1991 suggest that yields may have declined somewhat. One observer estimates that yields may have declined as much as 20 percent in 1991.[107] Precise details are not available.

Freshwater shrimp: DINAAC reports that growers report varying yields depending on the methods employed. Growers using the continuous growth method are achieving annual yields from 1.5-3.0 t per hectare. Growers using the batch method report higher annual yields of 3.0-4.0 t per hectare.[108] The authors have no information on yields at individual farms.

Panamanian growth rates and yields appear to be somewhat less than those reported in some other Latin American countries (Colombia, Guatemala, Honduras, and Peru). A variety of reasons appears to account for this difference:

Dry season: While seasurface temperatures are favorable, strong winds during the dry season cause considerable evaporative cooling which appears to lower pond temperatures, especially as many Panamanian ponds are more shallow than is common elsewhere in Latin America. The evaporation could also affect salinities.[109] Industry sources point out that average yields per crop during most of the year are comparable to Central American averages, but that yields are depressed for 4.5-5.0 months during the dry season. Yields generally fall by about 40 percent during this period.[110] Other Central American countries also report pond operations are impaired by dry seasons, but the problem does not appear to be as significant as in Panama.

Small-scale growers: Panama has a relatively large number of small, inefficient growers. If these operations were excluded, Panamanian results would be closer to the Central American average.[111]

Species: Panamanian growers use *P. stylirostris* to a greater extent than other Central American growers. As *P. stylirostris* yields are less than those obtained with *P. vannamei*, overall Panamanian yields are less than reported in neighboring countries which use much higher proportions of *P. vannamei*.

Virtually no published data is available on Panamanian production costs. One report made some estimates for a 1982 Inter-American Development Bank (IDB) loan. (See: "XV. Government Policy.") The data compiled suggested favorable returns, but is now dated.[112] One report indicated that Agromarina in 1984 estimated production costs at $3.85 per kilogram.[113] Some data was compiled by the Consejo Nacional de Inversiones in 1987, but is not enough to prepare useful production cost estimates.[114] Panamanian companies retain yield data as internal company information and most companies are reluctant to release this and other information on operations. Many farms appear, however, to have relatively high operating costs.[115]

Some observers believe that Panamanian production costs tend to be higher than in many other Latin American countries.[116] This is due to a variety of reasons, including poor site selection, pond design, and management. Apparently the early growers underestimated the technical complexities of culturing shrimp. Few had any previous experience with aquaculture. Many assumed that they would easily replicate Agromarina's technical methods and quickly generate extremely high earnings. They often launched operations without adequate feasibility studies or contracting competent technical advisors. As a result, several growers are now saddled with relatively high operating costs. Small farms in particular appear to have high fixed costs and do not benefit from the economies of scale achieved at the larger farms. The industry's failure to expand significantly during the 1980s tends to confirm that operating costs are relatively high. Some observers suggest that some farms may be correcting problems and reducing costs, but this can not yet be confirmed. Preliminary results for 1991 suggest that production costs may have increased at some farms because of the lower yields.

IX. FEED

Almost all Panamanian farms employ some form of nutrient inputs to augment natural productivity and improve yields. Most attempt to minimize feed costs by employing a fertilization program.

A. Fertilization

A substantial number of farmers fertilize their ponds to induce algal blooms on which the shrimp can feed.[117] This is the most economical method of adding nutrient inputs. One estimate suggests that about 35 percent of Panamanian farms use commercial fertilizers based on urea (NPK12-24-12).[118] Some growers use a variety of locally available substances such as chicken dung and even fish wastes.[119] Few farm managers, however, have more than a cursory understanding of the various nutrients (phosphorus, nitrogen, and potassium) needed to promote desired algal growth.[120] As a result, much of the fertilizer used is not applied efficiently. Little information has been published worldwide on fertilization of brackishwater ponds and only limited research has been conducted in Panama on the subject. Most growers have applied fertilizer without assessing results statistically, a critical measure in developing cost-effective application systems.

B. Balanced feeds

More than half of Panamanian growers also use commercial rations for supplemental feeding. One source reports that about 65 percent use commercial (pelleted) feeds. The others either do not apply supplemental feed, or use only minimal quantities. A few growers use feeds they produce themselves or trash fish.[121]

Panama has the most important shrimp feed industry in Central America. It is the only Central American country with an important fishmeal industry and thus has an advantage over neighboring countries. Fishmeal, a major feed ingredient, is cheaper in Panama than in other Latin American countries (appendix G1 and figure 5). This is primarily due to lower protein content, but other factors may be involved.[122] The country's excellent transportation network also assists feed manufacturers. Each of the three major Panamanian plants have the capacity to produce about 50 t of feed daily.[123]

Three companies (INASA, Rivoflavia, and Nutricion Animal [NASA]) currently produce most of the pelleted shrimp feed used in Panama, although a few additional feed companies manufacturing small quantities are also active.

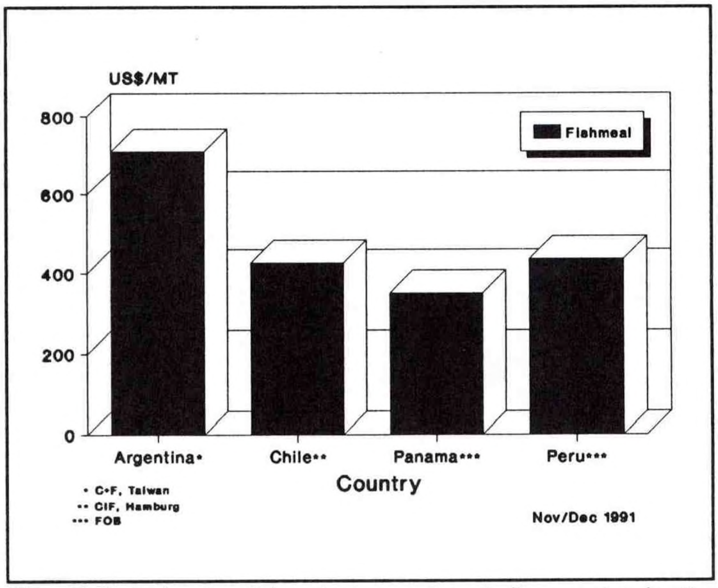


Figure 5.--Latin America. Fishmeal prices are lower in Panama than in other Latin American countries.

INASA: INASA is owned by the same company which owns Camaronera de Coclé (COMACO). No information on the company's feed operation is currently available. The associate shrimp farm manger, however, assures the authors that he is obtaining excellent results using the INASA feed.[124]

NASA: The company's mill is located at Volcan (near David) in Chiriquí Province. The U.S. company, Zeigler Brothers, licenses the company to produce its feed in Panama.[125] Zeigler provides vitamin supplements, trace elements, and ingredients not available in Panama. The NASA plant has the capacity to produce about 1,400 t monthly. One of its main clients is Agromarina. The company not only supplies the domestic market, but also ships to neighboring countries (Colombia, Costa Rica, Cuba, and Honduras). Special formulas are prepared for three different species (*P. vannamei*, *P. stylirostris*, and *P. schmitti*).[126] The company's product line includes a variety of formulas with different protein and fat contents.

Rivoflavia: The company is owned by one of Panama's wealthiest families, the Riandes. It is part of an integrated operation including a farm (Aquachame), packing plant, and feed mill. The mill is located near David. Much of the shrimp feed technology and many of the inputs are obtained from the U.S. company, Rangen. No information on the operation is currently available.

Others: One grower reports purchasing from another company, Laro.[127] No details on this company are currently available.

Panamanian feed companies use a variety of ingredients. Major inputs include fishmeal, animal offal, cow bone meal, rice and other grain husks, broken rice, soya, corn, fish oil, and wheat flour. Other ingredients can also include premixes (with vitamins and nutritional supplements), vitamin C, ascorbic acid (to tolerate high temperatures), calcium carbonate, and small quantities of oxytetracycline, furacin, and furanate. The companies produce shrimp feeds ranging in protein content from 20 to 40 percent (appendix G2).[128]

Feed mills are not currently using one potentially important feed input, discarded shrimp heads. Panamanian feed mills have lacked access to shrimp heads because the trawler fishermen dehead most of their catch at sea. This is unlikely to change as it would be costly for the fishermen to land the whole animal for meal production. In addition, attempting to save the entire animal could impair the quality of the shrimp catch. This is a substantial loss as the heads are particularly valuable feed ingredients. The increasing harvests of cultured shrimp, however, may make it possible to use some heads for feed production. The growers deliver their harvest whole to the processing plants and as a result the discarded heads could be used for meal production. No packer, however, has yet installed a plant to produce such meal.[129]

Panamanian feed companies both supply the domestic market and export to neighboring Central and South American countries. Despite the success of some feed companies with export sales, the Government has felt restrictive import regulations necessary to protect the domestic market. Such restrictions have impaired operations at some farms in the past. Some observers believe that the restrictions have adversely affected Panama's shrimp growers by enabling domestic feed companies to maintain relatively high prices. As feed is a major cost factor at many farms, the impact adversely affects farm margins. In addition, the import restrictions limit competition and reduce the incentive for feed companies to improve product quality. Government officials continue to stress the need for protecting the developing feed industry. The current Government is studying the situation, however, and has reportedly agreed to permit some imports.[130]

The authors have received a variety of often conflicting reports on feed quality. Grower opinions are often based, however, on mostly anecdotal evidence instead of systematically compiled statistical data. Actual data on feed quality is not available to the authors.

Growers: Some growers complain about the quality of feed available in Panama. While observers report that the quality of feed has improved, most remain convinced that Panamanian feed is still more expensive and of lower quality than that available in many other countries.[131] Growers are especially critical of water stability and nutrient levels.[132] One important grower has been attempting to import feed from other countries, but has had trouble with Government import restrictions.[133] One report suggests that two of the three major companies enjoy a "fairly good" reputation, but dismisses products from other companies.[134] Some growers believe that Panamanian feed companies have difficulty producing high quality feeds because of the problems described above with local ingredients, especially fishmeal.[135] Some observers insist that Panamanian fishmeal is inferior to that produced in Chile and Peru.[136]

Feed manufacturers: Panamanian feed manufacturers strongly deny the charges of inferior Panamanian feed. One manufacturer asserts that such charges are "totally wrong" and insists that exports to several neighboring countries demonstrate the strong acceptance of Panamanian feeds.[137] Feed manufactures tend to attribute disappointing results to rainfall and temperature factors as well as faulty pond management.

The authors know of no academic study evaluating the often conflicting statements of growers and the feed companies. In fairness to the feed companies, the authors have noted that Latin American growers often attribute a wide range of problems to feed quality. In some cases their complaints are no doubt justified; in other cases such charges reflect a tendency of growers to question the quality of supplies rather than the pond management regime for which they are responsible. Feed companies often bear the brunt of such criticism because feed constitutes such a major portion of overall farm operating expenses.

The Panamanian feed companies initially experimented with different pellet sizes. Company specialists assumed that different pellet sizes would be necessary for shrimp at various growth stages. Currently, the companies have shifted production to 1/8 inch pellets which they have concluded is suitable for both nursery and growout operations.[138]

Some research work on shrimp nutrition and feed has been conducted in Panama. The major effort has been conducted by Agromarina, but that data is not publicly available. Some of the feed companies have their own research programs. NASA's contract with Zeigler gives them access to their considerable research capability. DINAAC researchers have also carried out some studies at EEAS. (See: "XVIII. Technical Capacity: Research.") Some feed/nutrition work has also been reported at the University of Panama.[139] Such research is important for the industry's future development. Panamanian growers cannot simply use formulae developed in other countries. The characteristics and nutrient content of major ingredients (fishmeal, grains, etc.) often vary sharply from country to country.[140] Low content of specific nutrients in locally available inputs can limit yields.

X. COMPANIES

Despite the technical success at Panama's first farm, many subsequent growers experienced considerable difficulties. Some of the better managed semi-intensive farms are now achieving improved results, but most growers continue to report serious technical and financial problems. Available data from local observers on 1990 and 1991 results vary widely. Industry sources were optimistic that the arrest of General Noriega and a more stable political and economic environment would create conditions permitting the industry to expand. Many projected significant growth during the 1990s. This does not appear to have occurred in either 1990 or 1991. Available information suggests that many Panamanian marine growers are making little progress in expanding harvests and continue to experience serious financial difficulties. While local observers are especially pessimistic concerning the country's poorly financed small extensive farms, such difficulties are not limited solely to these small farms. Even Panama's leading farm, Agromarina, for example, reported difficulties in 1990 and 1991.

A. Industry overview

The authors have received varying accounts concerning the financial status of Panamanian shrimp culture companies. Observers have reported serious managerial and technical problems throughout the 1980s.[141] Even industry leader Agromarina has not been immune from these problems. Some companies have made progress in resolving major difficulties and reported improved results. Several independent observers, for example, have commented on the well-managed Aquachame farm. Other companies, however, especially the smaller farms, continue to report serious financial problems.[142] Government officials report that many farms apparently continue to report operational problems and are achieving at best only marginal earnings.[143] Observers have mixed views on the industry's prospects. Some insist that steady progress is now being achieved, especially by the major semi-intensive farms and important harvest increases will be reported during the 1990s.[144] Other industry observers are less optimistic and believe that the industry's financial situation is not very promising.[145]

A variety of factors has contributed to the problems experienced by growers. These ongoing problems combined with serious disease problems and insufficient rainfall explain the disappointing results reported at many farms during 1991.[146] The reasons for the difficulties vary from company to company. Some of the major problems include:

Growing conditions are generally favorable, but the dry season poses some complex technical problems. (See: "III. Growing Conditions.")

Difficult economic conditions since the 1982 debt crisis have adversely affected some growers, but similar problems were prevalent in other Latin American countries. Beginning in 1987, Panamanian economic conditions worsened as relations deteriorated between General Noriega and the U.S. Government. Since the 1989 arrest of General Noriega, however, conditions have been improving. (See: "IV. Economic Conditions.")

Inadequate planning explains many of the initial difficulties experienced by the Panamanian companies. Many farms were built at a relatively early stage of the industry's development. As a result, inadequate sites were often selected and the farms poorly designed. These faulty facilities continue to impair operations. Many companies report relatively high cost structures.[147] (See: "VIII. Yields/Production Costs.")

Limited technical capabilities have been another serious constraint. The failure of many growers to seek competent technical assistance appears to be a major contributing factor to the continuing difficulties. Some observers also report a general reluctance of growers to exchange information with their colleagues, further restricting the dissemination of technical information. There appears to be no effective effort on the part of individual companies or the industry association (APAC) to promote the dissemination of technical improvements.

Poor farm management appears to be a factor at several small farms. Shrimp farming is a part-time activity for many growers operating small ponds. A number of these growers seem unwilling to convert their efforts to serious commercial operations. Many will not stock, for example, their ponds unless inexpensive wild pl are available. Thus ponds lie idled, even though pl is almost always available from local hatcheries.[148]

Ineffective Government policies have provided only limited support, despite some serious effort. The Government's major fishery development plan proved only marginally effective and has been sharply curtailed. Some Government policies, such as high land lease fees, may have had a significant adverse impact on investment.[149] (See: "XV. Government Policies.")

Observers differ somewhat on the evaluation of the Panamanian shrimp culture companies. Many companies reportedly need to revise management techniques and to make design modifications at their farms. One observer reports, however, that many seem to be waiting for government support programs, rather than initiating such improvements.[150] Except for Agromarina, little information is available on individual farms because few companies release details on their operations. Most observers agree that only a few companies are reporting significant improvements. One 1989 report suggested that only two large companies (Agromarina and another company) were doing relatively well. A 1990 report suggested that a few companies (Acuimar and Acuachame) seemed to be making progress.

Observers offer various assessments of prospects at Panamanian farms during the 1990s. Some industry sources are optimistically projecting significant harvest increases. They report that the fall of the Noriega Government has resulted in renewed interest in the industry.[151] The area of ponds does appear to be steadily expanding. Some farms have expanded or are planning expansion programs. One big new project is planned. (See: "V. Area/Location.") These observers suggest that the growing experience of Panamanian growers and the expanding training of local technicians is preparing the groundwork for an important expansion of the industry during the 1990s. Not all observers, however, are as optimistic. Some experts point to continuing problems at many farms.[152] Observers note that few new groups appear to be entering the industry. Other experts are especially concerned with yields below those reported in some other countries. The difficulties experienced in 1991 and the failure to report harvest increases are not encouraging.

B. Farms

1. Marine species

The first Panamanian shrimp farm (Agromarina) was built in the early 1970s.[153] The Government estimated that there were about 38 farms in 1989 (appendix E2).[154] One observer estimates that there are currently about 46 farms, including 6 large farms (200-485 ha), 9 medium farms (50-199) and 31 small

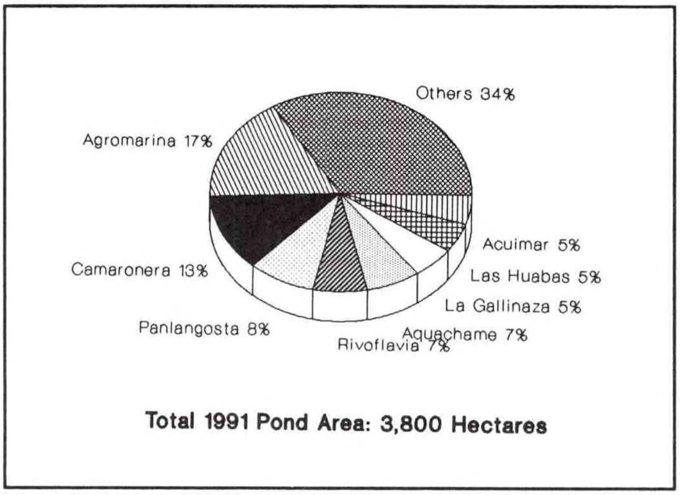


Figure 6.--Panama. The Panamanian shrimp culture industry is dominated by a few large farms.

farms (10-49 ha). The larger farms operate the bulk of Panama's pond area (appendices H1-2 and figure 6). Several farms appear to be inactive. Another observer estimates that only about 25 farms actually cultured shrimp in 1990.[155]

Available details on selected farms are as follows:

Acuimar: The company was organized in 1988 and opened 71 ha of ponds in 1989. New ponds are under construction and plans called for completing 200 ha by the end of 1991.[156] The farm is located on land leased from the Government located at Parita, Herrera. It is a joint venture with a foreign investor. The major construction underway suggests that the company is achieving some success, but no information is currently available on either harvests or yields.

Agromarina de Panama: Panama's first farm was founded by a U.S. company, Ralston Purina,[157] but sold in 1986 to the Granada Corporation in Houston, Texas.[158] Agromarina continues to be the largest and most technically advanced Panamanian farm. Ralston Purina initiated preliminary studies in 1972 and built a commercial farm at Aguadulce in 1974. The 34 ha Agromarina farm consisted of 6 nursery ponds and 30 small growout ponds.[159] Along with the growout operations, Agromarina also built the country's first shrimp hatchery at Veracruz, Panama Province. (See: "XIV. Postlarvae Supplies: Hatcheries.") After 4 years of growout operations, Agromarina decided to expand pond area to 200 hectares. The company built relatively small ponds (10 ha) each and a small number of nursery ponds. The successful hatchery program has not only guaranteed seedstock for the company's own ponds, but provided income through pl and nauplii sales. Agromarina has since further expanded pond area to 625 ha (appendix H1).[160] The company through 1989 reported improving results and unconfirmed reports suggested that it was planing to nearly double its pond area from 625 ha to 1,125 hectares. The company employs a 1-month nursery phase followed by a 110-day growout cycle.[161] Harvests increased from 1,300 t in 1986 to 1,700 t in 1989. This was one-half of Panama's total cultured shrimp production in 1989. The number of crops per year has varied, but averaged about 2.9 in 1989. Annual yields reached 2.7 t per hectare.[162] Harvests have, however, since declined. The 1990 harvest was about 1,300 t and declined even further to only about 1,100 t in 1991.[163] The company reported disappointing yields both during the rainy season and dry season. Agromarina has diversified export sales and is placing some whole shrimp in U.S. regional markets.[164]

Aquachame: Some local observers believe that the company, owned by the Riande family, is one of Panama's better managed shrimp farms. One recent visitor described the complex as "a first class business operation." The company initiated operations in 1980 and benefitted from the COFINA loan program. Available information suggests that a major pond expansion program was conducted in 1990 and the farm currently has over 650 ha of ponds (appendix H2).[165] The 1991 harvest totaled about 1,040 t in 1991 and the company anticipates nearly 1,700 t in 1992. Company officials estimate they achieved yields of up to 1.2 t per ha during 1991. The company harvests shrimp ranging from 14-20 grams and averaging 15 grams. Aquachame is part of a highly integrated operation. The group operates a maturation hatchery. (See: "XIV. Postlarvae Supplies: Hatcheries.") The company also includes a feed mill and a packing plant. The feed conversion ratio is 1.3-1.4. One observer reports that the company has successfully completed a major cost reduction program. The farm site has space for an additional 700-800 ha of ponds and the company plans to actually build about 150 ha of ponds in 1992. The harvest is marketed as "Riande Shrimp," primarily in Europe, although small quantities are also shipped to the United States and Canada. The major European markets are Spain, France, and Belgium where the company reports it has been able to obtain stable prices.[166]

Boca de Parita: The Sociedad Camaronera "Boca de

Photo 1.*--Panama. Aerial view of Agromaria farm with salt ponds in foreground.*
© Jorge Pang, Agromarina

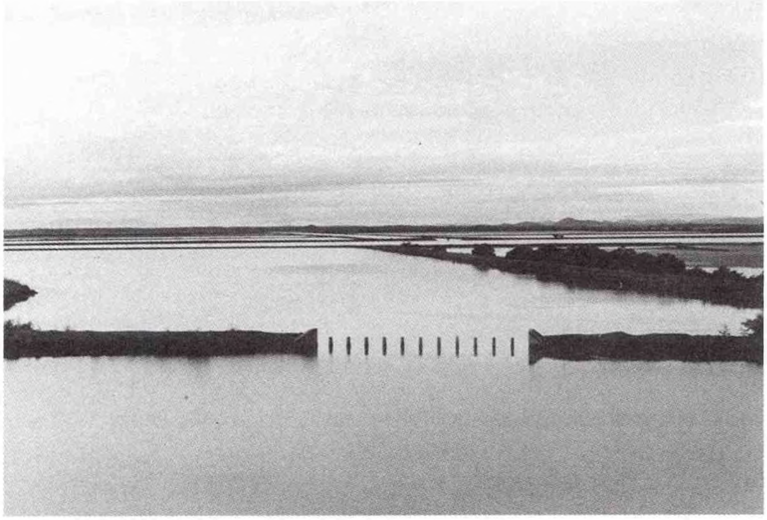


Photo 2.*--Panama. Agromarina's growout ponds are some of the most productive in Panama. © Jorge Pang, Agromarina*

Photo 3.*--Panama. Harvested shrimp awaiting processing at the Agromarina farm.*
© Jorge Pang, Agromarina

Parita" is an association of 35 low-income families in Herrera which the Ministerio de Desarrollo Agropecuario (MIDA) is attempting to help culture shrimp. The area of ponds has varied somewhat during the 1980s,[167] but the association has apparently reported only marginal results. Various sources have suggested that the group operated from 40-70 ha of ponds during the 1980s (appendices H1-2). Farm officials report, however, that they actually operated 55 ha of a total of about 100 ha during 1991. Harvests totaled about 0.35 t per ha and about two crops are harvested each year, giving annual yields of 0.7 t per hectare.[168]

Camaronera de Coclé (COMACO): This farm was originally founded as Camaronera de Natá (CANASA). It was another of the early farms to open in Panama and was owned by one of the most powerful business families in the country. The farm is located close to the Agromarina farm near Aguadulce, Coclé on land purchased outright. Growout operations were initiated in 1983. CANASA originally built 300 ha of pond and subsequently expanded. The company also built a hatchery near San Carlos.[169] (See: "XIV. Postlarvae Supplies: Hatcheries.") CANASA was plagued by a variety of operational problems, including a serious disease outbreak in 1987.[170] The farm was forced into a receivership under the Banco Nacional de Panama (BNP).[171] The new owner took control of the farm in June 1990 and changed the company's name to Camaronera de Coclé (CAMACO). The farm has about 620 ha of ponds (appendices H1-2). One 1990 report suggested relatively low yields of only about 0.5 t per ha as a result of the extensive growout system.[172] The new owner closed the farm in 1991 for major design changes, especially the water system.[173] As a result the 1991 harvests were limited to only 130 tons. Only 175 ha of ponds were utilized during the final months of 1991 giving yields of about 0.7 t per hectare. The company is still reworking some of the ponds, but is projecting a 1992 harvest of nearly 500 tons using a new semi-intensive system. Company officials estimate that space exists for upwards of 2,000 ha of ponds. The new company has also redesigned its San Carlos hatchery. (See: "XIV. Postlarvae Supplies: Hatcheries.") COMACO obtains feed from its feed affiliate, INASA.[174]

Camaronera el Nanzal: The company was founded in 1982 and has built 50 ha of ponds in two stages at Anton, Coclé (appendices H1-2). Investment funds were obtained as part of the MIDA/IDB project.

Finca Marina Limosillo: The owners have reported some difficulty obtaining the necessary Government concession for this farm. After 8 years of effort the concession was finally grated in 1991. The farm reports operating 32 ha of semi-intensive ponds in 1991 and reportedly harvested about 20 t of shrimp.[175] Financing has been obtained from the BNP to build an additional 8 ha of ponds in 1992 with intensive modifications. The concession granted by the Government permits up to 50 ha of ponds. Pl are purchased from wild collectors as well as nearby hatcheries.

(La) Galinaza: The company built about 200 ha of extensive ponds in 1981 on Government land located at Aguadulce, Coclé. The farm operates an extensive system, although small amounts of feed are sometimes applied. The pond area has not been expanded (appendices H1-2). The owner, Roberto Ramos, invested his own funds. The farm conducts only one harvest annually and reports an annual yield of 0.2 t per hectare.[176] No other details are available.

(Las) Guavas: Available data show a considerable variation in the estimated pond area, from 80-185 ha of ponds. The farm is an semi-intensive system. The owner experimented with polyculture using oysters along with shrimp, but the trials have been suspended due to low growth rates.[177]

Granjas Marinas: The company initiated operations in 1982. It currently operates about 120 ha of growout ponds at its Bejuco/Chame, Panama farm (appendices H1-2). Government officials report that the company has significantly improved its administrative and technical capacity. It received funds as part of the MIDA/IDB development program. Granjas Marinas built a hatchery at Punta Chame in 1985. (See: "XIV. Postlarvae Supplies: Hatcheries.") The company reported crops of about 1.2 t per ha in 1990.[178]

Grupo de Salineros: A group of salt producers joined in 1985 to culture shrimp in salt ponds near Aguadulce, Coclé. Observers differ on the area of ponds they operate. One observer estimated 90 ha of ponds, but it may be substantially larger.[179]

Hacienda El Rosario: This farm was opened in 1985. The owner participated in the MIDA/IDB program. The farm has about 175 ha of ponds and is located at Penonomé, Coclé (appendix H2). It reportedly has considerable area for expansion.

(Las) Huabas: The company was founded in 1980 and the first ponds completed in 1984. Observers differ on the area of ponds at its Parita, Herrera farm (appendices H1-2). The owners participated in the MIDA/IDB development program.

Pacumar: Unconfirmed reports suggest that U.S. and Panamanian investors plan to build a large new farm. The current status of the project, however, is unknown.

Panlangosta: Panama's second shrimp farm was opened in 1977 at Aguadulce, Panama.[180] The farm has 100 ha of ponds built on land leased from the Corporación Bayano/Autoridad Fortunaria and has since expanded to about 320 ha (appendices H1-2). No information is available on actual harvests because company officials report that they do not release such data to the public.[181] The company stocks substantial quantities of *P. stylirostris*. One report indicates that Panlangosta uses wild-collected seedstock.[182] Another report suggests that they also use pl produced at their own hatchery.[183] The company is reportedly a joint venture with foreign investors.

Rachung: This small farm was opened in 1974. It operates about 45 ha of ponds on land leased from Agromarina (appendices H1-2).

Other farms: Panama has about 15 commercial operations but a much larger number of generally unsuccessful, or at best marginal, small-scale operations.

2. Freshwater species

The first commercial freshwater farm was built by **CAMARPAN** during the 1970s. The company attempted to culture *M. rosenbergii* and built a hatchery near the Paitilla Airport and growout ponds at Bique. The company functioned for a year, but eventually closed for undisclosed reasons.[184] Currently a number of small-scale growers culture freshwater shrimp, but no commercial farms are known to be in operation.

C. Industry group

Panamanian growers decided that they needed a permanent industry association to promote their interests. They founded the Asociación Panameña de Acucultores (APAC) in 1989.[185] APAC promotes all sectors of the country's aquaculture industry. The shrimp growers are the major commercial participants, but there are also finfish and mollusk farmers. Some local observers question the effectiveness of the group. Many believe that it has generated little effective coordination among growers on a variety of technical, financial, and promotional matters. The authors know of no material prepared by the association to promote or publicize the industry.

XI. HARVESTS

Almost all of the Panamanian harvest is marine shrimp. The freshwater harvest accounts for only small quantities. Precise country-wide harvest data is difficult to obtain. Some data published by the Panamanian Government appears to significantly understate pond harvests (appendix D1). The most likely statistics suggest that the harvest totaled about 3,500 t in 1989 (appendix D2). The authors have obtained little hard data on more current harvests. Different observers offer widely varied estimates of 1990 results, but the harvest appears to have been about 3,000-3,500 tons. Most observers, but not all, report problems in 1991 which impaired harvests, but there is sharp disagreement over the precise quantity harvested.

A. Marine shrimp

Panamanian growers have been trying to culture shrimp nearly as long as Ecuadorean growers, but with less success. Despite two decades of effort, Panamanian harvests are still relatively limited. Growers did report some increases in harvest levels during the 1980s. Harvests are, however, still far below what some Government and industry leaders had initially anticipated.[186] Several countries are now reporting sharply higher harvests and surpassing Panamanian results. Panama was Latin America's second most important producer of cultured shrimp, after Ecuador, until 1988. Growers in five countries (Colombia, Mexico, and Honduras) currently harvest more shrimp than in Panama (appendix D7).

Assessing annual harvests trends has proven difficult because of the lack of reliable statistical data. Available data suggest that harvests were increasing, albeit slowly through 1989 (appendix D1-2). Some observers expressed considerable optimism for 1990 and 1991 and were convinced that Panamanian growers would report substantial gains during the 1990s. Others are much less optimistic, however, and point to the continuing problems at many farms.

1970s: The shrimp culture industry began in 1972 when Agromarina initiated trial runs. The company achieved favorable results and applied in 1974 to build a commercial farm.

1978-82: Agromarina's success caused considerable interest and beginning in 1978 a number of individuals and groups began building farms. Optimistic reports began appearing in the Panamanian press.[187] Most investors, however, had little or no technical capability and lacked a full appreciation of the specialized knowledge required. As a result, the yields achieved were generally disappointing. Many individuals assumed that because a large U.S. corporation like Ralston Purina had invested in shrimp culture that fabulous profits were assured.[188] Little care was given to site selection or farm design. Difficulties were encountered with pl (incorrect species identification) and a variety of pond management problems with which the earliest growers were not technically prepared to cope.[189] The summer dry season presented a particularly difficult problem. The generally poor results prompted the Government in 1979 to initiate various assistance programs culminating in the MIDA/IDB loan project. (See: "XV. Government Policy" and "XIX. Foreign Assistance.")

1983-1988: Government promotional efforts, including the MIDA/IDB project, did not achieve the desired results. Growers continued to report technical and managerial problems. The 1982 debt crisis and the later disruptions associated with the Noriega Government added to the industry's problems. Growers reported difficulty obtaining postlarval seedstock, especially *P. vannamei* postlarvae.[190] Only a few companies resolved their management and farm design problems. Several companies had to scale back expansion plans and others closed. Panamanian Government officials reported that marine shrimp harvests increased, albeit slowly. One observer who visited Panama in 1986 reported signs of "positive growth."[191] Accurate time line data on Panamanian harvests, however, is not readily available for much of the 1980s.[192] Some available data suggests that harvests were relatively stable at 2,600-3,000 t during 1985-87, but increased to 3,500 t in 1988 (appendix D2).

1989-90: Growers did not increase their harvests in 1989 which remained at about 3,500 t (appendix D2). Some observers pointed to the economic and political instability associated with the Noriega regime as a major factor limiting the industry's expansion. Few

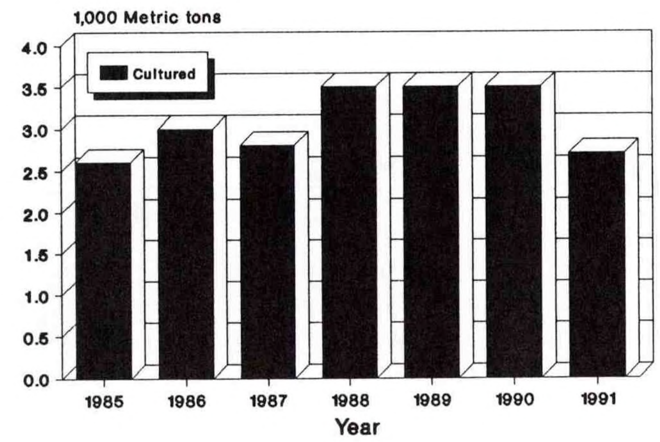


Figure 7.--Panama. Available data suggests that cultured shrimp harvests have declined since 1989.

investors wanted to make significant new commitments. Growers again in 1990 failed to expand harvests, which may have actually declined (figure 7). One Government source estimates a 1990 harvest of only 3,100 t and this figure is confirmed by at least one industry source.[193] Such a harvest would mean a decline of 400 t from the 1989 harvest. The limited available data, however, is contradictory. One press report suggested a 1990 harvest of about 4,000 tons.[194] Local sources indicate that in 1990 more than 20 percent of the country's ponds were idle and that some farms were reporting serious operating and financial problems.[195] Many other farms reported only minimal profits and several companies have reportedly closed their farms.[196]

1991: The authors have been able to obtain little hard data on operations at most farms. The large Agromarina farm had plans to expand, but encountered considerable difficulties during 1991. At least one large new farm was planned, but few details are available on actual construction.[197] Several small farms apparently closed. Despite the problems, some observers estimate that as much as 4,500 ha of ponds were reportedly in operation during 1991.[198] Postlarvae appear to have been available in abundant quantities during much of the year, but some of the hatcheries ceased production during certain months because of disease problems.[199] Local observers were particularly optimistic at the beginning of the 1991. One preliminary reports suggested that the 1991 harvest through August totaled 1,800 t, nearly 20 percent above 1990 harvest levels for the same

Photo 4.*--Harvesting shrimp at the Agromarina farm.* © *Jorge Pang, Agromarina*

period.[200] Obtaining reliable data on the 1991 harvest has proven extremely frustrating and the authors have been unable to obtain verifiable data.[201] Various local observers offer a wide range of estimates. The Panamanian Government estimates that the full year harvest was over 5,700 tons.[202] Most industry observers, however report a substantially lower harvest. One observer projected a harvest of about 4,000 tons.[203] Other observers believe that the 1991 harvest declined from 1990 levels. Most local observers estimated the 1991 harvest at from 2,500-3,500 tons.[204] All local observers report that most farmers experienced serious problems in 1991, especially with disease (*Vibrio*) and inadequate precipitation.[205] One observer estimates that 1991 yields may have declined over 20 percent from 1990 levels.[206] The disease problems also lowered survival rates at several farms, many of which reported harvesting somewhat small sizes. Given the range of available estimates, the authors are unable at this time to authoritatively assess the actual 1991 harvests. The agreement of local observers on the serious problems experienced suggests, however, that actual harvests may prove closer to the lower range of available estimates.

1990s: Some industry sources are still optimistic that they can expand harvests significantly during the 1990s.[207] Some believe that Panama will also report substantial harvest increases in 1992 and 1993. Many believe that the economic and political chaos during the Noriega years substantially impaired industry results and that it should now begin a rapid period of growth. One observer reports that harvests should double in the next few years.[208] Other observers, however, are less optimistic. Many are concerned about continuing problems in the industry.[209] The limited 1991 harvest disappointed many growers who were expecting a turn-around. As a result some local observers are concluding that actual harvest increases may occur only slowly.

Panamanian growers generally harvest relatively small-sized shrimp. Observers vary as to the precise size distribution of the harvest. One observer estimates that small and medium shrimp (41-60 count)[210] shrimp constitute about 60 percent of the harvest and extra small (61+ count) shrimp about 30 percent of the harvest. Only a small amount of the shrimp produced is medium-large size (36-40 count).[211] Another observer estimated in 1991 that small and medium sizes constituted 75 percent of the harvest.[212] Almost all of the rest was even smaller shrimp.[213] Another observer reports that small and medium shrimp were 35-40 percent of the harvest and extra smalls about 50 percent.[214] Many growers reportedly harvested unusually small shrimp during 1991, especially *P. vannamei*.

While the precise size/count distribution is unclear, the Panamanian harvest does appear to differ substantially from the size ratio of harvests in Ecuador and several other Latin American countries. The reasons for harvesting small shrimp is unclear. Some growers have adopted a harvest system yielding smaller shrimp.[215] Several observers believe that the large harvest of small shrimp may be due to poor quality domestic feed.[216] (See: "IX. Feed.") Other observers report that it is probably the result of the long dry season. Some report that growers are harvesting small shrimp to supply processors producing breaded shrimp.[217]

B. Freshwater shrimp

Panamanian growers harvests only limited quantities of freshwater shrimp. Available harvest data is imprecise and varies from source to source. All observers confirm, however, that growers are only harvesting small quantities. Harvests in recent years have ranged from a high of 16 t (1986) to a low of 5 t (1989) (appendix C2).[218] Government officials estimate the 1990 harvest at about 10 tons.[219]

XII. PROCESSING

Panama has the largest shrimp processing industry in Central America. About 30 packing plants currently process shrimp, although several are reporting financial problems. The processing industry was originally centered in Panama City, but many packers moved to Vacamonte after the port opened in the late 1970s. Packers now operate at both Vacamonte (Panama) and Aguadulce (Coclé). One observer claims that many established packers prefer to process trawler caught shrimp.[220] Profit margins are reportedly higher for the large shrimp produced by the trawler fishermen than the generally smaller sizes the growers harvest. (See: "XI. Harvests.") Only seven packers reportedly process cultured shrimp. The principal packers handling cultured shrimp in each Province are: **Panama** (Inversiones Yemika, Marina Pac, and Pescadores Independientes), **Coclé** (Agromarina, Palangosta, and Vigomar), and **Herrera** (Pynmar). Two shrimp farms (Agromarina and Palangosta) have their own processing facilities.[221] Some of the cultured shrimp is used to produce breaded products.[222] Much of the breaded product appears to be the less expensive "basket style" shrimp.[223] The breaded production, however, comprises only a small portion of overall shrimp production.[224]

Growers in Panama appear to be producing a quality product which is well received on the international market. The authors know of no empirical study assessing quality, but price levels are in part the market's assessment of product quality. Price data compiled by DIGEREMA indicates that Panamanian exporters receive a substantial premium for their cultured white shrimp. Cultured shrimp tended to sell for about 20-30 percent more than wild-caught shrimp, the precise price differential depending on the size count.[225] Panamanian prices appear to be comparable to those received by Ecuadorean growers (appendix K8). Some observers report that Panamanian and some other Central American cultured shrimp vary somewhat in color from the Ecuadorean shrimp, but that there is no significant quality difference.[226]

XIII. MARKETS

A. Domestic

Panama markets only a small portion of its shrimp catch domestically. The domestic shrimp market is limited by the country's small population and consumption has increased little in recent years.[227] This probably reflects, at least in part, the difficult economic conditions in Panama during recent years. **Commercial** fishermen and **growers** sell only small amounts for domestic consumption. One observer estimates that less than 10 percent of the commercial catch and pond harvest is sold to local wholesalers for the domestic market. The rest is sold to processing companies for export, although small amounts of that production (probably about 5 percent) is also marketed domestically. **Artisanal** fishermen, on the other hand, sell almost all of their catch (over 95 percent) on the domestic market, usually in areas close to the landing sites.[228]

Panamanian officials would like to increase domestic fisheries consumption. Officials believe that an inefficient marketing system is one of the factors limiting consumption. The Government is now planning to build a new fisheries market at El Marañón to help promote consumption in the country's largest city and major market, Panama City. The Government has reportedly obtained some financing from Japan.[229]

B. Exports

Panama is the primary shrimp exporter in Central America. The country exported between 6,000-11,000 t (product weight) of shrimp annually during the 1980s (appendix K3). Shipments reached record levels in 1985 and 1986 as a result of the excellent trawl catches in those years. Only a small part of those exports were cultured shrimp. Growers have since increased harvests which have become an important part of Panama's overall shrimp production. One observer estimates that cultured exports totaled about 1,800 in 1991.[230] While trawl catches and pond harvests vary from year to year, it now appears that growers are producing about half of the country's exports of the valuable *Penaeid* shrimp.

Panamanian growers export almost all of their harvest. One observer estimates that export shipments account for more than 90 percent of the pond harvest.[231] Most farms rely on the packing companies or brokers to market their shrimp overseas. About 80 percent of the harvest is handled in this manner. A few larger farms marketed their own product, accounting for about 20 percent of the harvest.

Panamanian exporters have traditionally marketed their shrimp primarily in the nearby United States (figure 8). The United States continues to be the dominant market, but increasing quantities are now also being shipped to European countries, especially Spain.

United States: The United States is the principal market for Panamanian shrimp (appendix K2 and figure 8). No separate marketing data is available exclusively for cultured shrimp, but such shipments are an increasingly important element of the country's overall shrimp production (appendix K3) and, as a result, cultured shrimp exports probably reflect the general pattern of overall shrimp exports. During the 1980s, shipments to the United States varied from 94-100 percent of all shrimp exports (appendix K3). The proportion has declined somewhat in recent years and in 1990 fell below 90 percent for the first time. The United States imposes few tariffs and other trade restrictions on fishery products and Panamanian growers have thus had easy access to the large U.S. market. In addition, the volume of trade with the United States makes it relatively easy to contract

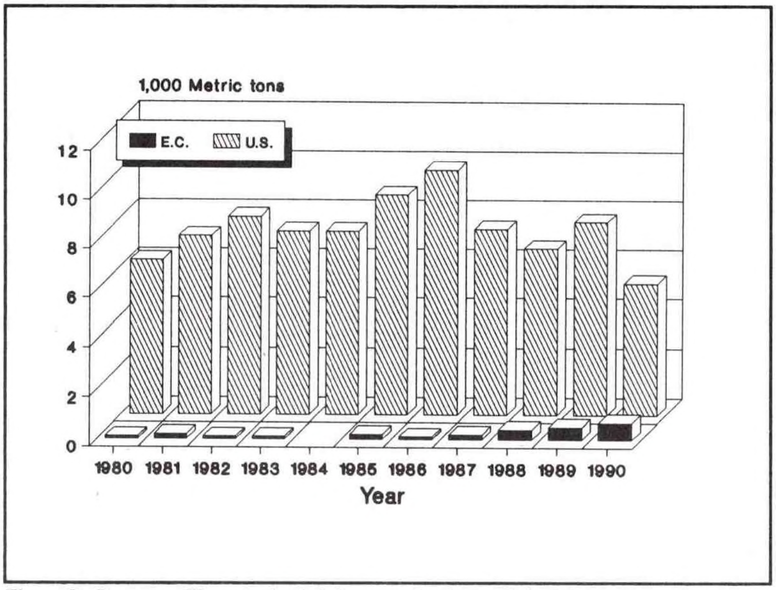


Figure 8.--Panama. The principal shrimp market is the United States, but shipments to Europe are increasing.

refrigerated containers. Panamanian shipments during the 1980s have varied from a record 9,900 t worth $78 million (1987) to a low of 6,200 worth $46 million (1980) (appendix K4 and figure 8).[232] Shipments peaked in 1986 and have since declined by nearly 50 percent in both quantity and value (figure 9). The 1990 season proved to be an especially poor year (appendix D2) and shipments to the United States declined to only 5,300 tons (appendix K4).[233] The principal reason for the declining quantity since 1986 has been the continuing plunge of the trawler catch. Exports during 1991 have shown only a slight improvement to 5,900 t, still a relatively depressed level. The U.S. has been a dependable market, but exporters have noted the price declines during the 1980s in the real value of shrimp and have begun to open alternative markets in Europe. Most exports to the United States are shipped as raw, frozen heads off product (appendices K1-2 and K5).[234] Panama also ships breaded shrimp to the United States. While the breaded quantities are relatively small, Panama was the only important foreign supplier to the United States in 1990 (appendix K6).

Europe: The European Community (EC) is the only other important market for Panamanian shrimp. EC countries have primarily imported coldwater shrimp, but several member countries have begun to import increasing quantities of tropical shrimp[235] and several Latin American countries, including Panama, are benefitting from this trend. The EC has, however, not proved to be an easy market to enter. Latin American exporters report great difficulty in dealing with the restrictive EC trade regulations.[236] Growers also report difficulties in contracting refrigerated containers.[237] Even so, Panamanian shipments are increasing and totaled nearly 700 t in 1990 (appendix K3 and figure 8). Unconfirmed reports suggest a continued significant increase in 1991, but no details are yet available. Many observers believe that the potential exists for Latin American exporters to substantially increase shipments to Europe during the 1990s.[238] Strong European currencies and favorable prices for whole shrimp have attracted the interest of exporters in Panama and other Latin American countries.[239] Exporters entering the European market have had to shift processing patterns from the raw frozen tails demanded in the United States to product forms (mostly whole shrimp) demanded by European consumers. Panamanian exports to the EC are largely whole and cooked peeled shrimp. Specific product forms include: whole, unshelled (raw, cooked frozen, and cooked unfrozen) tails (raw frozen shell-on and peeled, peeled cooked frozen, and canned peeled and cooked). The leading EC market is Spain which accounted for over 90 percent of 1990 EC shrimp imports from Panama (appendix K7 and figure 10).[240] Small sales during various years have

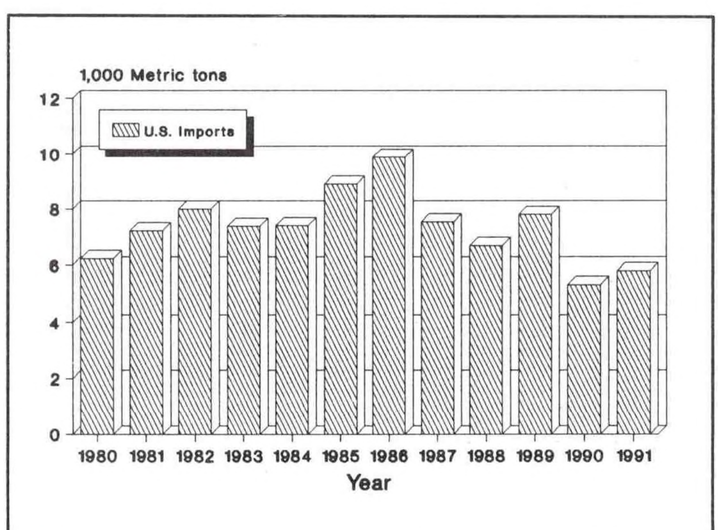


Figure 9.--United States. Shrimp imports from Panama have been declining since 1986, primarily as a result of the problems in the capture fishery.

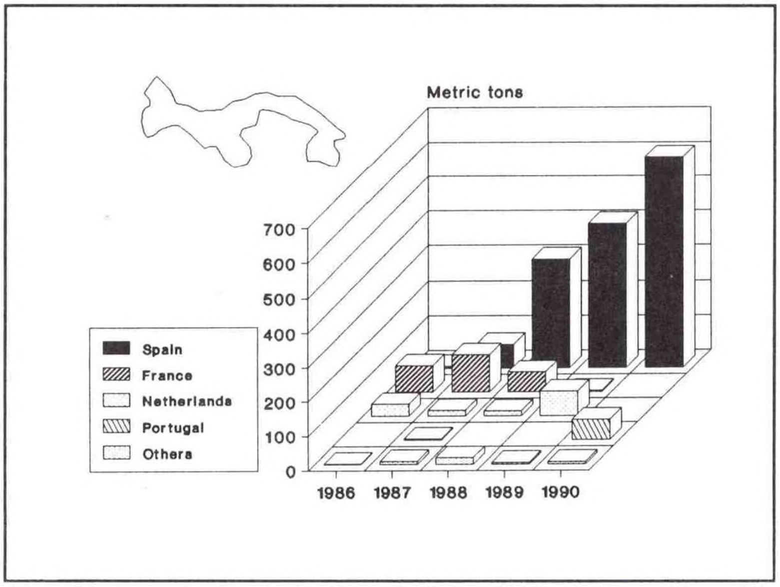


Figure 10.--European Community. Spain is Panama's principal European market, although several other countries import small quantities.

been reported to several other EC countries, but the quantities have been limited. While the quantities are still relatively small, Panama has a longer history of shipping to European countries than several other Latin American countries. This may reflect the greater Panamanian sophistication in export trade.

Japan: Japan is the world's largest market for imported shrimp,[241] but Panamanian exporters have not yet entered the market (appendix K3). Other Latin American countries report sales to Japan, but this is almost exclusively trawler-caught shrimp. Panamanian exporters could possibly achieve some success in the Japanese market with trawler caught pink shrimp, but significant future shipments of cultured white shrimp appear unlikely.[242] Japanese access to the massive harvest of lower-priced Chinese white shrimp and increasing competition with Asian black tigers will make it difficult to sell higher-priced Panamanian whites.[243] Most of the Latin American countries currently exporting shrimp to Japan are shipping species other than whites: tropical pinks (Brazil and Colombia), tropical browns (Mexico), and coldwater reds (Argentina) (appendix K9).[244]

C. Imports

Panama does not report any shrimp imports.

XIV. POSTLARVAE SUPPLIES

Postlarval seedstock is supplied by both domestic wild collectors and hatcheries. The availability of wild pl in estuaries and the substantial production of hatchery pl appears to be one important advantage enjoyed by Panamanian growers. While pl shortages have affected some farms in the past, pl currently appear to be readily available to growers, in many cases, at prices far below those in other Latin American countries. Even so, some Panamanian growers, especially the small extensive operations with narrow profit margins, are generally reluctant to purchase pl and often attempt to collect it themselves.[245]

Observers report that most Latin American growers prefer wild seedstock because of its superior survivability and growth characteristics.[246] Ecuadorean growers, for example, report somewhat higher prices for wild pl than the hatchery produced postlarvae.[247] This preference for wild pl is especially pronounced among small Panamanian growers, but may in their case reflect resistance to higher-priced hatchery postlarvae.[248] Small-scale growers are accustomed to extremely inexpensive wild pl and many reject higher-priced hatchery pl even when wild pl are unavailable. Some differences, however,

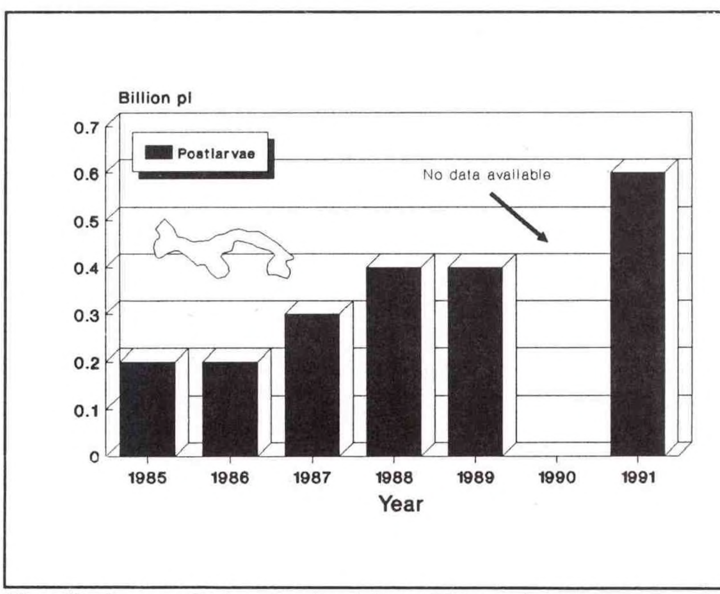


Figure 11.--Panama. Postlarval seedstock demand is increasing as growers expand pond area.

apparently exist among Panamanian observers over the use of wild or hatchery postlarvae.[249]

Current Panamanian seedstock demand is not known with any precession. The authors know of no study estimating demand. Rough calculations can be made, however based on stocking densities and pond area (appendices J2-4). Such calculations suggest 1991 demand at over 0.5 billion pl (appendix J4 and figure 11), given current pond area estimates of about 4,200 ha (appendix E1).[250] Although little hard data is available on wild pl collection, the artisanal collectors clearly cannot fully supply current demand, especially during seasonal fluctuations in pl abundance. Fortunately Panama has developed one of the most productive hatchery industries in Latin America. Panamanian hatcheries are not only capable of supplying domestic growers,[251] but also exporting increasing quantities of both pl and nauplii. (The export of wild pl is prohibited to protect wild stocks on which the domestic trawl fishery is dependent.) The opening of a large new hatchery (PLC) in 1991, as well as expansion at the major hatchery (Agromarina) and the construction of a new hatchery (PACPL) in 1992 will further enhance the country's seedstock production capability.

Future pl demand is even more difficult to project. Accepting a 9,000 ha estimate of available Pacific sites and assuming gradual improvements in methods and yields, growers could well require as much as 3.5 billion pl by the year 2000.[252] Even such a large increase in demand can probably be met by Panamanian suppliers. Wild collections can be increased somewhat, but most of the increase will have to come from expanded hatchery production.

The future of the hatchery industry looks promising, but faces some difficult challenges. The current hatcheries are producing pl with considerable success. Expansion currently underway will substantially increase their production capacity. The experience being gained by Panamanian technicians and the developing hatchery infrastructure is providing a base which should permit substantial further growth during the 1990s. The limited success with closed-cycle maturation, however, is a continuing problem which will probably keep the hatchery industry dependent on wild broodstock and spawners for the foreseeable future. Domestic demand and prices for pl in Panama have lagged behind that prevalent in other Latin American countries. Hatchery operators have reported considerable difficulty in selling to independent domestic farms.[253] As a result, Panamanian hatcheries have focused more on export markets and are thus vulnerable to fluctuations on those markets.

A. Wild collection

Wild pl is an important source of seedstock for growers. Many Panamanian growers refuse to consider hatchery postlarvae. About half of the pl used to stock ponds are still collected in the wild.[254] As a result, fluctuations in the supply of wild pl can cause major disruptions at Panamanian farms.

Panamanian pl collectors report a marked seasonal pattern in pl availability, both in quantity and species distribution. (See: "VI. Species.") Artisanal fishermen collect at least some pl year-round.[255] During much of the year, however, only small quantities of *P. vannamei* pl are available. *P. stylirostris* is often the only species available in sufficient quantities to stock ponds. Most collectors concentrate their efforts primarily during the twice monthly high tides in the "albinas" and along the inner reaches of the mangrove estuaries. One observer reports that the area of salinas in Los Santos is a particularly good area to collect postlarvae.[256] Middlemen/marketers employ groups of artisanal fishermen who collect the pl and deliver it to specially equipped transport trucks.[257] Rotenone is used to eliminate the pl of the unwanted finfish species in each consignment. The artisanal collectors are equipped with small hand nets, a bucket, and a transport tank mounted on a boat or truck.[258] The preferred time to collect is the morning and evening when temperatures are low, but collection efforts are often scheduled to take advantage of the high tides, making it impossible to vary the time of day.

Panamanian pl collectors are reportedly improving their collection and delivery practices. One observer noted in 1986 that few growers had an adequate knowledge of collection techniques and reported relatively high mortality rates.[259] More current accounts suggest that considerable progress has been made. When pl are collected during the mid day, plastic bags with ice are now used to maintain water temperatures at 20-25° C for transport. The fishermen watch for behavioral changes which can indicate oxygen depletion. If the pl come to the top of the bucket/container or begin sporadic jumping, the collectors stop to change the water. The small pools where the pl are held in nets are also watched. While changing the water, the collectors remove material such as leaves, sticks, and mud. Some fishermen may change the water as many as three or four times. This procedure is designed to minimize stress on the pl and, as a result, limit mortalities. Deliveries to farms are generally made at densities of 1,000-2,000 pl per liter. Bottled oxygen is used to maintain dissolved oxygen levels at about 6-7 parts per million (ppm). Lower levels can cause stress-related mortalities and higher levels will result in excessive mortalities during the acclimatization process at the farms.

Substantial quantities of pl are being collected in Panama. The country's important wild shrimp resource provides an important source of wild pl for the growers and berried females for the hatcheries. The area of suitable habitat, particularly the large shelf area and substantial area of mud bottom estuary and mangrove forestry support the largest shrimp stock in Central America. Various authors have reviewed the role of mangroves in the life cycle of *Penaeid* shrimp.[260] Data on numbers of pl actually collected are not available. One source reports, however, that during 1990 about 55 percent of the pl used by shrimp growers was collected in the wild.[261] This would mean less than 0.3 billion pl, not including unwanted species. Observers have not reported any marked change in wild pl availability during 1991.[262]

Observers differ on the level of mortalities occurring during the collection and transportation process. Some report that pl mortalities in Panama are lower than in many other countries. One observer estimates that pl mortalities of only about 20 percent in the collection and transport phase.[263] The low mortalities may be due to the similar environmental conditions at the capture site and the ponds. Much of the pl is collected in the "albinas" which are adjacent to many ponds. Collectors transporting pl often use water taken from the nursery ponds in which the pl are to be stocked. Others dispute this favorable assessment and contend that Panamanian pl collection methods are wasteful, resulting in high mortalities.

Some specialists are worried about the lack of selection in the collection process.

Environmentalists: Observers are concerned that the removal of increasing numbers of pl is adversely affecting wild stocks of shrimp and other species. Growers currently use only two shrimp species, but collection techniques result in substantial mortalities of non-targeted species, not only of other shrimp species but of other marine organisms as well.[264]

Growers: One Government study concluded that current collection methods produce too much *P. stylirostris* pl which adversely affect grower yields.[265] (See: "VIII. Yields/Production Costs.") Growers would like deliveries with greater amounts of *P. vannamei* as well as smaller quantities of unwanted species which can complicate growout operations.

Postlarvae collectors receive some of the lowest prices prevalent anywhere in Latin America. Prices are well below those received, for example, by Ecuadorean collectors.[266] Panamanian growers thus have access to relatively inexpensive wild seedstock, although a substantial proportion is *P. stylirostris* instead of *P. vannamei*. (See: "VI. Species."). The low pl prices in Panama probably reflect the economic problems at the small Panamanian farms purchasing wild pl and the tendency of the more successful farms to use pl from associated hatcheries. Despite the low prices, Panamanian pl collectors report wide margins because of extremely low operating costs. Collectors report production costs of only about $0.55 per 1,000 pl (appendix J1). During 1990 and early 1991, collectors were selling pl at $1.00-1.50 per 1,000 postlarvae.[267]

Fluctuations in the availability of wild pl can have a crucial impact on farm operations. Most Panamanian growers, with the exception of the larger farms with their own hatcheries, stock completely or at least partially with wild postlarvae. The supply of wild pl, however, is not sufficient to meet the needs of local growers, especially during the dry season (December/January-May). Growers have for some time reported serious seasonal problems obtaining wild postlarvae. The problem became especially severe in 1984 and 1985.[268] Some observers report the natural supply of pl is declining and blame pl collectors. The authors know, however, of no detailed study confirming this decline or assessing the wild pl supply. Even if pl abundance is declining, many other factors besides collecting could be affecting the abundance.[269] Converting estuarine nursery habitat to growout ponds, for example, could have a major impact.[270] Fluctuations in pl availability could also be due to variety of climatic variables affecting shrimp stocks. (See "I. Capture Fishery.")

The Panamanian Government in 1988 decided to restrict the collection of wild postlarvae.[271] Capture fishermen were complaining that the collection of pl was adversely affecting their catches.[272] Fishermen had been reporting declining catches since 1985 (appendix D2) and some blamed the decline on the collection of wild postlarvae.[273] The Government had for many years imposed a seasonal shrimp closure to protect juvenile shrimp and limit fishing effort.

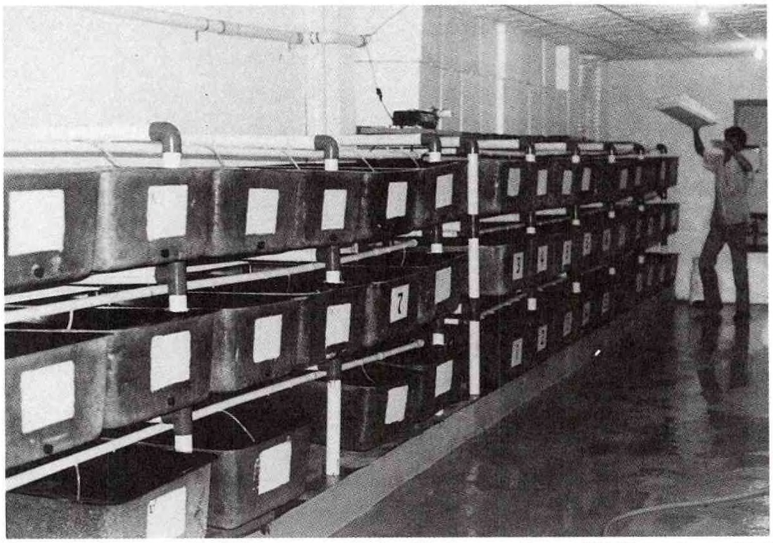


Photo 5.--Panama. Hatching room at the Pacific Larvae Centre (PLC) hatchery. PLC primarily produces nauplii for export. © *Ron Stanha, PLC*

Government officials reportedly concluded that growers could obtain adequate pl seedstock from hatcheries and that it was thus no longer necessary to collect wild postlarvae. As a result, they prohibited the collection of wild postlarvae. Growers complained, however, that hatchery pl was not available in adequate quantities and was substantially more expensive than wild-collected postlarvae. The Government reversed itself at the end of 1988 and authorized resumed wild pl collection.[274] The Government continues, however, to prohibit pl collection during the annual seasonal closure for the trawler fishermen as well as the export of wild postlarvae. (See: "I. Capture Fishery.")

B. Hatcheries

Panama was the first country in Latin America to open a marine shrimp hatchery. While the Ecuadorean hatchery industry[275] has since surpassed Panamanian production, Panama remains a regional leader and an important seedstock exporter. Four Panamanian hatcheries have attempted closed-cycle maturation (appendix I1). Most hatcheries continue, however, to report problems with the technical demand of closed-cycle operations.[276] Even industry leader Agromarina has experienced problems, especially with viruses. Most Panamanian hatcheries thus still depend primarily on wild gravid females for seedstock production.

Panama is emerging as a regional center for producing seedstock. It is not readily apparent why Panama is becoming such an important center. Panama does offer several advantages to hatchery managers. One industry source stresses water quality and temperature as important factors in Panama's success.[277] Another source, however, insists that other locations in Latin America probably have access to better quality water. All observers agree that water quality is a key factor for any hatchery. Panama has naturally occurring *P. vannamei* which it can source for broodstock. The country's central location and excellent transportation links give hatcheries the ability to ship throughout Latin America. Agromarina's nearly 2 decades of operations have played an important role in developing a cadre of trained individuals. One observer speculates that Panama's success has been basically a function of management and human resources.[278] Agromarina has provided experience for quite a number of technicians on which other hatcheries have drawn. While individual hatcheries try to retain their methods as proprietary information, movement of employees between hatcheries is helping to spread technology throughout the industry. Panamanian hatcheries can also offer technicians, especially highly-paid foreign experts, better living conditions than in the extremely isolated Ecuadorean hatcheries where local living conditions are often rudimentary.[279] This has proven an important factor in attracting and retaining staff.

There appears to be an expanding demand for seedstock in Latin America. Regional shrimp harvests are steadily increasing and no longer confined almost exclusively to Ecuador (appendix D7-8 and figure 12). Several countries (Brazil, Colombia, Guatemala, Honduras, and Mexico) are now harvesting increasing quantities of cultured shrimp. Many Pacific-coast countries (Colombia, Honduras, and Mexico) report, however, that *P. vannamei* and *P. stylirostris* pl are either unavailable, or only available in inadequate quantities to stock their expanding area of ponds. Most Atlantic/Caribbean coast growers without access to wild *P. vannamei* stocks (Belize, Brazil, Colombia, Dominican Republic, and Venezuela) have found that *P. vannamei* offers the best yields and are looking for hatcheries capable of supplying seedstock on a regular basis. Productive hatcheries are located, however, in only a few countries.[280] Panamanian hatcheries have been some of the few in Latin America capable of supplying that demand on a regular basis and permitted to do so by their government.[281]

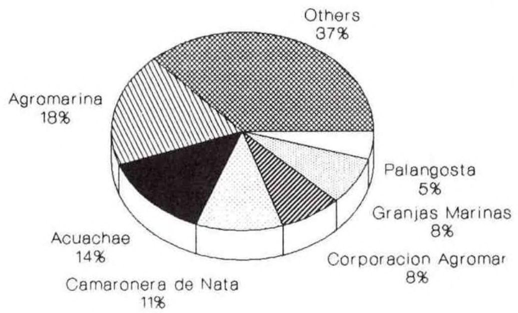


***Figure 12**--Latin America. Growers in the region are steadily increasing pond harvests, creating a rapidly rising demand for seedstock.*

Panamanian hatcheries initially concentrated on producing pl, but some are shifting production to nauplii. Foreign hatcheries and farms capable of using nauplii to produce pl are emerging as the primary market for Panamanian hatcheries. This is an important development because the growing demand for nauplii as opposed to pl is making it easier for Panamanian hatcheries to enter foreign markets. Shifting to nauplii helps to facilitate export trade. Shipping pl long distances is complicated and costly and can easily result in substantial mortalities Nauplii are much easier and less expensive to transport.

Panamanian hatcheries produce both freshwater and marine shrimp pl, although the important commercial operations are all for marine species. The authors know of nine hatcheries which operated during 1991.

1. Marine

Panamanian hatcheries, which many consider to be among the best in the world,[282] have been quite successful in producing postlarvae. Panamanian hatcheries report both increasing quantities and improved quality. The hatcheries supplied about 45 percent of the country's pl demand in 1990[283] and seem likely to surpass wild collections in 1991 or 1992. Observers disagree somewhat as to actual pl production levels, but Government officials estimate that six privately operated hatcheries averaged runs of 90 million pl monthly in 1989, or nearly 1 billion for the full year (appendix I1).[284] The capacity has increased and by the end of 1991 probably totaled 150-175 million pl per month, if the new PLC hatchery met expectations (appendix I2). This would mean an annual production capacity of about 2 billion postlarvae. Not only do the Panamanian hatcheries produce sizable quantities, but industry sources insist that survival and growth characteristics tend to be superior to most Ecuadorean hatcheries.[285]

Hatchery production costs in 1990 varied from about $3.50-5.50 per 1,000 pl and domestic prices ranged from $8.00-11.00 per 1,000 postlarvae.[286] Another observer reported domestic prices of $5.50 to $6.50 per 1,000 and export prices of $8.00-9.00 per 1,000.[287] Scattered reports suggest that 1991 nauplii and pl prices are about the same as in 1990. Agromarina, for example, cites prices of $1.50 per 1,000 nauplii and $8.50-11.50 per 1,000 pl (appendix J5).[288]

The prices charged by hatcheries are substantially above wild pl prices. (See: "XIV. Postlarvae Supply: Wild Collection".) Almost all of the Panamanian hatcheries are associated with shrimp farms (appendix I2).[289] Many of the independent growers not affiliated with hatcheries complain that pl prices are excessive. These complaints may be caused by comparison with

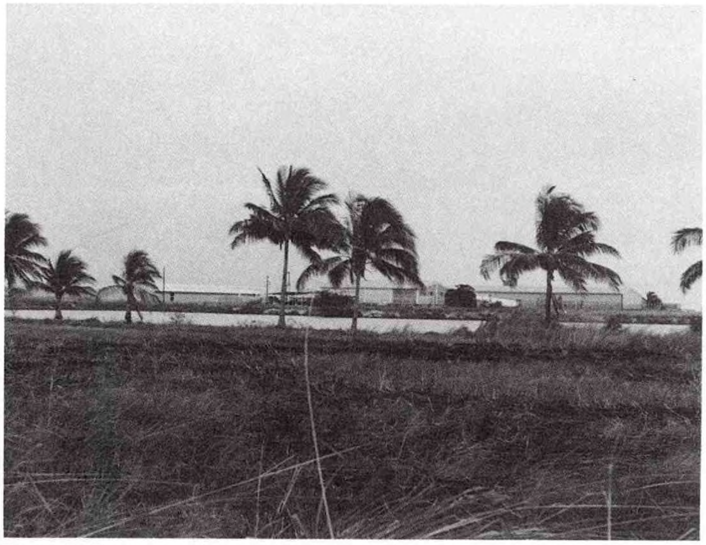


***Photo 6**.--Panama. New Pacific Larvae Centre hatchery located next to the Aquachame farm. © Ron Stanha, PLC*

the extremely low prices for which wild pl can be seasonally purchased from the collectors. Panamanian hatchery prices during 1989 and 1990 appeared to be somewhat lower than comparable Ecuadorean hatchery prices.[290] Domestic Panamanian prices also appear to be substantially below price levels in Colombia, and other important Latin American producing countries.[291]

Panamanian hatcheries are developing important export markets for seedstock. The hatcheries reportedly exported about 70 percent of their 1990 production.[292] Besides producing for their associated farms, Panamanian hatcheries export to other countries. One observer reports that earnings from pl export sales has been important to supplement earnings, or in some cases offset losses, from growout operations.[293] Panama exported over 10 million pl and 50 million nauplii monthly to other countries in the Western Hemisphere during 1989. Hatcheries increased shipments during 1990, but no data is available. Only hatchery pl is exported; the Panamanian Government prohibits the exportation of wild-collected postlarvae.[294]

The 1991-92 El Niño event currently underway could have a significant impact on Panamanian hatcheries. El Niño events can result in unusually high abundance of wild pl, especially in Ecuador. The abundance of wild pl in Ecuador can reach staggering levels during an El Niño. As a result, Ecuadorean prices for wild pl are likely to plunge in late 1991 or early 1992, perhaps below the level of hatchery production costs. Not only does the abundance depress prices, but many growers reject hatchery pl when they can obtain wild pl inexpensively. A substantial number of Ecuadorean hatcheries may close. One report from Ecuador estimates that 50-75 percent of the Ecuadorean hatcheries may have to close.[295] Hatcheries that continue to operate will turn their attention to export markets. Panamanian hatcheries will thus face a difficult market environment Although some of their export customers (especially Colombian hatcheries and farms) will not benefit from increased wild pl abundance, Ecuadorean hatcheries will try to increase their penetration of those markets. Some Panamanian hatcheries reportedly encountered increasing competition during 1991 from hard pressed Ecuadorean hatcheries which are finding their domestic markets drying up because of the improved availability of wild postlarvae.[296] The Ecuadorean hatcheries, as a result, have reportedly begun "dumping" nauplii and pl on any available market.[297] Some Panamanian hatcheries were adversely affected by such competition in 1991. One hatchery (PLC), however, reported considerable success in 1991.[298] Another hatchery (Agromarina) has revised prices and marketing strategy and hopes to achieve better results in 1992.

The future for Panamanian hatchery pl sales appears promising. The 19991-92 El Niño event may impair near-term results, but longer-term projections are more favorable. Newly developing growout industries, such as the one in Colombia, are a strong market which is heavily dependent on foreign hatcheries. As the Colombian shrimp culture industry expands, it is developing its own domestic hatchery industry.[299] The Colombian hatcheries, however, are reporting only limited success with maturation and have little access to wild berried females. Given the technical difficulty of closed-cycle maturation,[300] Colombian hatcheries will probably remain dependent on Ecuador and Panama for nauplii supplies at least through the 1990s. Some suggest that while Panama may have a limited potential for growout operations, it could support a major seedstock production center to supply growers in other countries. Some local industry spokesmen are especially optimistic about this potential and have been promoting the development of seedstock production.[301]

Data on the Panamanian hatcheries is limited, but several are reporting sustained production (figure 13). Available information on individual hatcheries is as follows:

Agromarina: Panama's leading hatchery is Agromarina which is located at Veracruz. The Agromarina hatchery is one of the most advanced

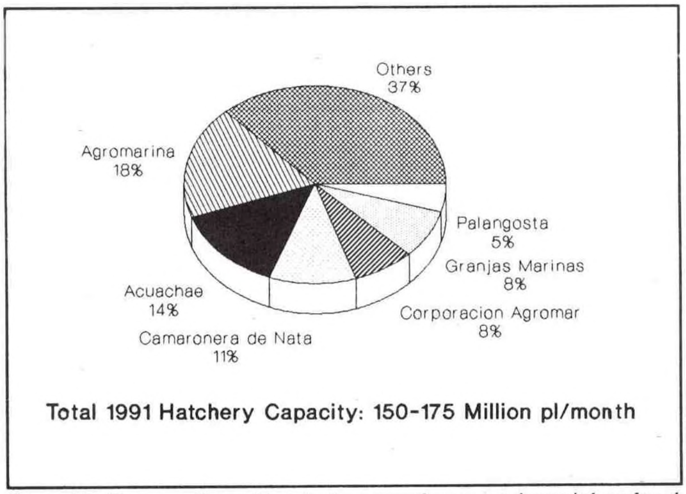


Figure 13.--Panama. Several hatcheries currently report substantial seedstock production.

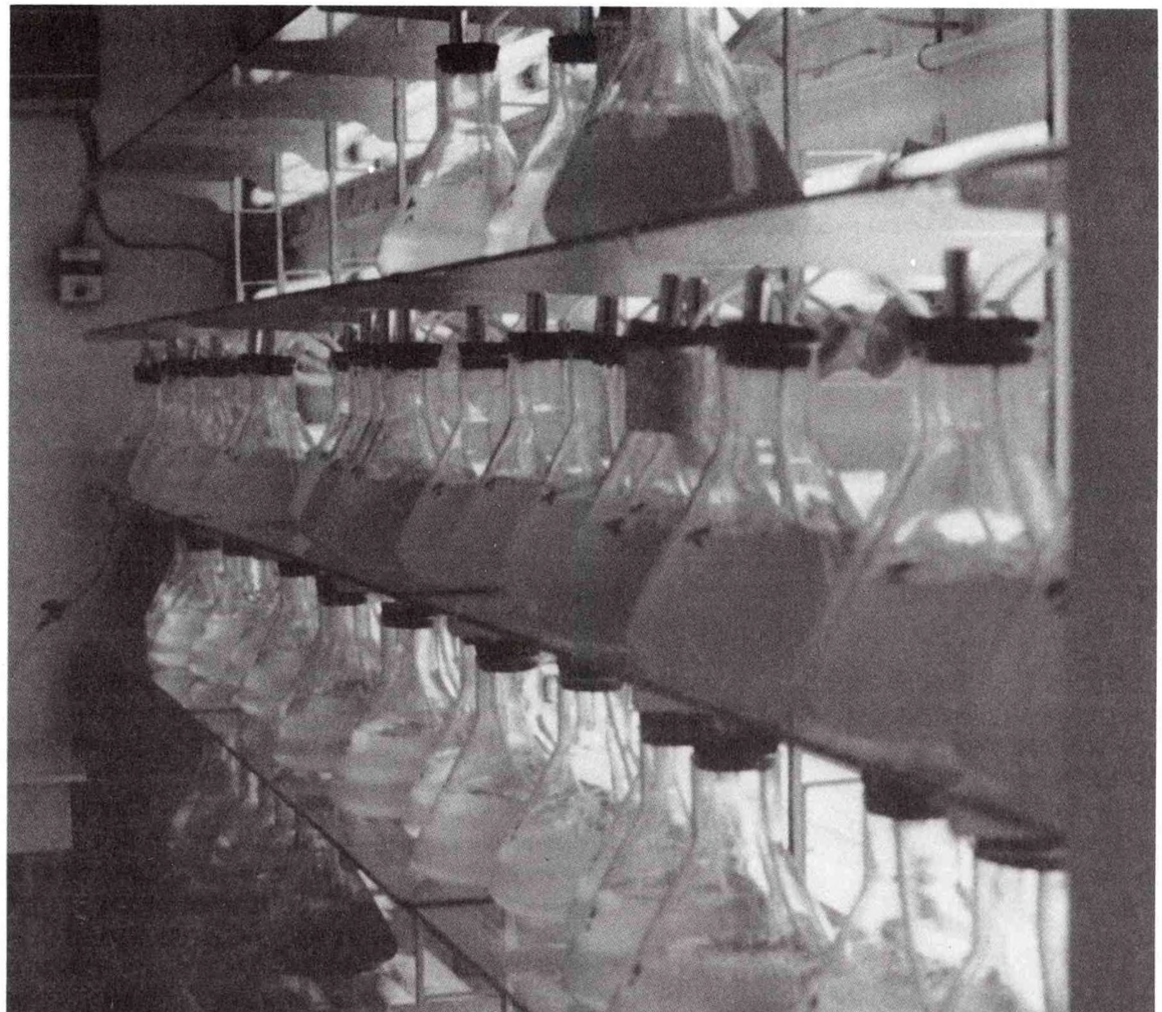


Photo 7.*--Panama. Algal room at the Agromarina hatchery. © Jorge Pang, Agromarina*

hatcheries in Latin America. The hatchery was initially built to produce about 5 million pl per month and later expanded to produce 30 million pl monthly. Larvae operations during 1987-89, however, were disrupted by a virus outbreak. The company reports that it had brought the virus under control by December 1989 without closing the hatchery. The company uses two trawlers under special Government permits to collect broodstock.[302] While they had little problem obtaining broodstock through 1989, spawners became very scare during the second half of 1990. The company reported much improved broodstock availability during 1991.[303] As of July 1990, the hatchery was producing about 30 million pl per month (appendix I2). The company during mid-1990 maintained 4,000 female broodstock in 95 tanks (4.6 m diameter) and was producing about 200 million nauplii per month.[304] Company officials are projecting future production of 300-400 million nauplii per month.[305] About 50 percent of the hatchery's production is for the company's own growout ponds. Much of Agromarina's seedstock exports are shipped as nauplii. The company, for example, has stopped supplying pl to Colombian growers and now only supplies nauplii to hatcheries in that country.[306] Company officials report that shipping nauplii is easier because smaller containers are required, thus avoiding scheduling problems with airlines.[307] They may eventually build a second hatchery for pl production and use the current Veracruz facility exclusively for nauplii production. Agromarina reported in 1990 that they projected total nauplii sales of 1.5 billion. The company advertised prices in 1990 of $1.25 per 1,000 nauplii and $8.00 per 1,000 pl (FOB Panama).[308] Agromarina's largest export sales are to Colombia, but it also sells to Costa Rica, Honduras, and the United States and has recently added customers in Brazil and Venezuela. Agromarina hoped to enter the Mexican[309] and Peruvian market in 1991.[310] Pl production during 1991 was similar to 1990, but Agromarina reported increasing marketing problems. Ecuadorean hatcheries are increasing export sales which are competing with Agromarina and the other Panamanian hatcheries.[311] As a result, Agromarina's sales in the especially important Colombian market were impaired in 1991. The company has revised its marketing strategy and believes it will be more competitive in Colombia and other export markets during 1992.[312]

(Corporacion) Agromar: The company originally obtained a concession to build growout ponds, but has not done so. Agromar instead built a hatchery at Chame in 1986. It reportedly has the capability of producing about 15 million pl per month, but data on actual production are not available.

Aquachame: The hatchery is located at Punta Chame. It was opened in 1987 and has the capacity to produce 20-25 million pl per month. Reports received in early 1992 suggest that the capacity has been increased to 40 million pl per month, but generally averages about 30 million. The hatchery reportedly has maturation facilities, but few details are available on maturation operations. Aquachame owns a trawler which is used to collect adult broodstock.[313] One report suggests that maturation results are generally on a par with Ecuadorean hatcheries, but not yet up to Agromarina's standards.

COMACO: The hatchery is located at San Carlos and has the capacity to produce 15-20 million pl per month (appendix I2), although some reports suggest a larger capacity.[314] The hatchery, which has recently changed ownership, was formerly known as CANASA. Data on actual production runs in 1991 suggest that they are now averaging about 20 million pl per month.[315]

Granjas Marinas: The hatchery located at Bejuco has no maturation facilities and purchases nauplii from other hatcheries. It has the capacity of producing 10-15 million pl per month (appendix I2), although some observers have provided a wider range of estimates.[316]

DINAAC/Maricultura del Pacifico: This small hatchery is operated by DINAAC. It was initially projected as a commercial-scale hatchery,[317] but has since been operated as a research hatchery producing only about 1 million pl per month.

Pacific Larvae Centre: The Pacific Larvae Centre (PLC) has opened a large new nauplii production operation. It is the newest and only hatchery devoted exclusively to nauplii production. Construction was completed in June 1991 and the first nauplii shipments were reported in July. PLC produced about 16 million nauplii in July 1991, but hopes to soon increase production to about 60-70 million nauplii per month (appendix I2). Plans call for doubling production during 1992.[318] The hatchery operates by catching and breeding adults to produce nauplii, primarily for the export market. Company officials say they may eventually attempt closed-cycle maturation, but currently believes that significant production can be achieved by using wild animals.[319] The PLC operation will substantially increase available seedstock supplies to both Panamanian and foreign growers. PLC plans to produce both *P.*

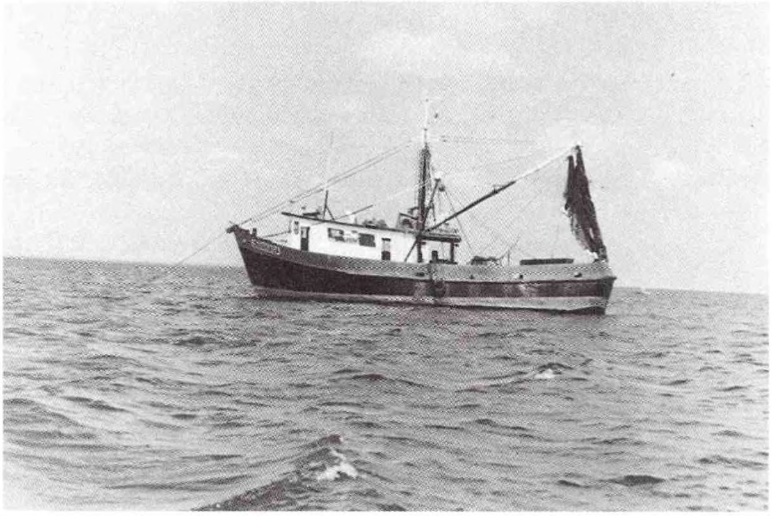


Photo 8.--*Panama. Agromarina obtains adult broodstock with this vessel in the Gulf of Panama. © Jorge Pang, Agromarina*

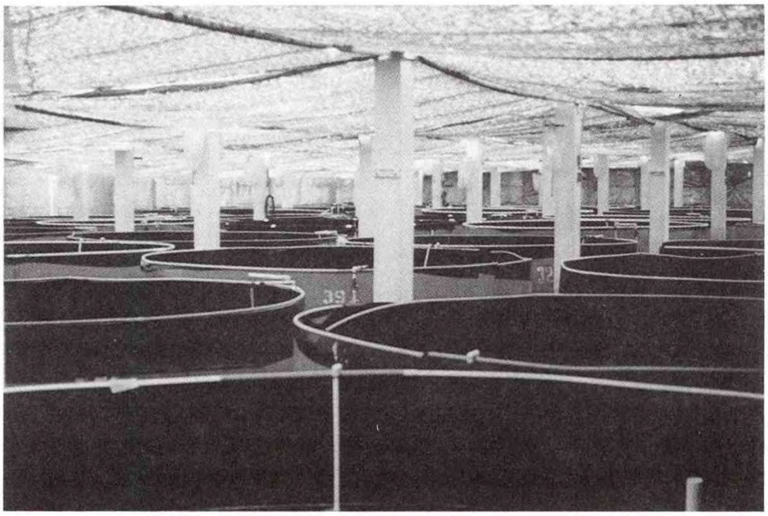


Photo 9.--*Panama. Agromarina is the oldest operating shrimp hatchery in Latin America. © Jorge Pang, Agromarina*

Photo 10.--*Panama. Transferring juveniles to growout ponds. © Jorge Pang, Agromarina*

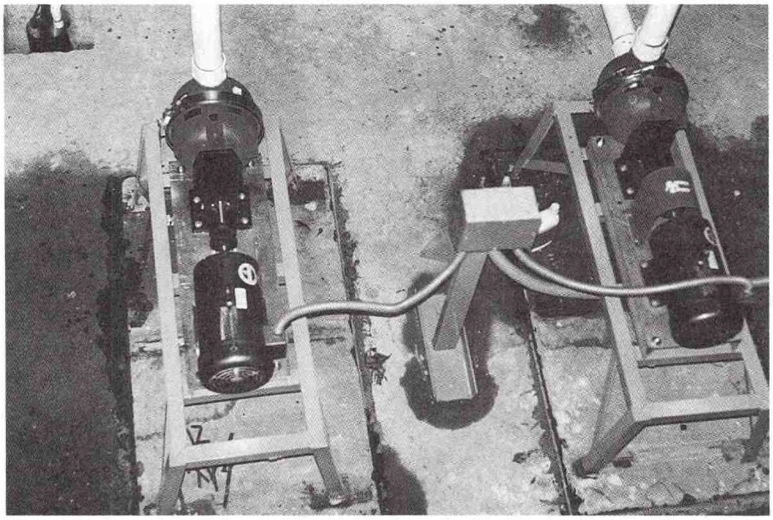


Photo 11.--Panama. Main seawater pumps at the Pacific Larvae Centre. © *Ron Stanha, PLC*

demonstration projects and farmers who operate small ponds. Some pl is also exported (to Colombia, Cuba, Dominican Republic, Venezuela, and other countries). The hatchery is operated entirely by Panamanian biologists who have conducted training programs for students and growers from various Latin American countries.[325] Broodstock for the hatchery is raised at two DINAAC Centers, Gualaca and Lago Gatún. Pl during 1990 were being sold at about $18 per 1,000 postlarvae.

vannamei and *P. stylirostris* nauplii, depending on client requirements. Initial production has been *P. vannamei* because orders to date have been for that species. PLC eventually hopes to expand production to about 210-240 million nauplii monthly.[320] Company officials insist that their competitive prices and high quality is allowing them to compete successfully with the Ecuadorean hatcheries.[321] The company offers nauplii at $0.80 per 1,000 (FOB Panama) for non-contracted orders.[322]

Pacific Postlarvae (PACPL): An investment group plans to build a hatchery to produce pl near the existing PLC nauplii hatchery. Current plans call for initiating construction in 1992.

Panlangosta: This hatchery is located at Aguadulce. The production capacity is about 5-10 million per month (appendix I2), although one source suggests a much larger capacity.[323] The company is using *P. stylirostris* and reported 1991 runs of 3-4 million per month.[324]

2. Freshwater

All of the freshwater shrimp (*M. rosenbergii*) pl used in Panama is produced in hatcheries. The Taiwan Aid Mission has helped train some Panamanian biologists in freshwater shrimp reproduction. (See: "XIX. Foreign Assistance.")

DINAAC opened a hatchery at Carrasquilla near Panama City in 1982 and latter redesigned it to produce about 0.1 million pl annually (appendix I1). The pl are primarily used to supply DINAAC

XV. GOVERNMENT POLICY

The Panamanian Government established the Dirección Nacional de Acuicultura (DINAAC) within MIDA during 1976 to promote the aquaculture industry. DINAAC has focused much of its efforts on finfish to improve domestic food production, but the agency has also shown some interest in shrimp culture. DINAAC first began working with shrimp culture in 1977, but initial activities were limited. DINAAC officials subsequently concluded that shrimp culture offered particularly promising commercial opportunities and decided to promote the industry.

DINAAC expanded its shrimp culture activities in 1982 as part of a $20 million fisheries development program, a major commitment for the Panamanian Government. The program was designed to promote the aquaculture industry and included two subprograms: 1) finfish to supply local markets and 2) shrimp to generate export revenues. The shrimp subprogram included several components, including a credit line for private pond construction and a Government hatchery, research center, and technical assistance effort.[326] The subprogram was designed to assist the private companies attempting growout operations by providing technical data and helping to train company employees.[327] MIDA planned to finance the construction of 1,500 ha of shrimp ponds for small and medium sized farms.[328] Funding was obtained from the Inter-American Development Bank (IDB) and the credit line administered through the Banco Nacional de Panama (BNP).[329] The $20 million project was funded by the IDB ($13 million) and MIDA ($7 million). The IDB has not yet completed a thorough assessment of the program, but some preliminary observations are available. Only a small portion of the credit line was actually utilized. The BNP reportedly had difficulty finding qualified growers and requested that the initial limitation on farm size be increased. About 500 ha of ponds for 15 different growers were finally built under this program with $3.7 million in IDB credits. The original plans were to build semi-intensive farms, but the growers involved had such limited technical backgrounds that they used mostly extensive methods.[330] Growers were restricted to building farms of no more than 200 hectares.[331] A variety of problems restricted loan disbursements.[332] Some observers report that several growers did not meet their repayment schedules and the IDB closed the credit line in 1986. The BNP seized farms that were unable to comply with the BNP/IDB repayment schedules and offered them for sale to other investors interested in reactivating the operations.[333] IDB officials in Panama report that tentative findings suggest limited success since only about half of the growers had good repayment records.[334] Other aspects of the program were modified. The hatchery was never built, but the Government did build the EEAS research center and has conducted some important shrimp culture research there. (See: "XVIII. Technical Capability: Research".)

The Panamanian Government sees the shrimp culture industry as a potentially important economic sector. The Government has, however, only a limited capability to assist the industry. It has already sponsored the most extensive promotional effort in Central America, although industry groups have questioned the program's effectiveness. Government efforts have included the following:

Credit: Agencies such as the Corporacion Financiera Nacional (COFINA) and the BNP have offered credits. (See "XVII. Credit.") Government efforts, however, are currently limited by Panama's financial problems. Officials are hesitant to initiate any major credit program given the poor results achieved by the MIDA/IDB project. This has led to an essentially *laissez faire* policy toward the industry.[335]

Disease assessment: DINAAC organized the First Course on Pathology of *Penaeids* in Central America during 1991. The course was conducted by Dr. David Conroy.[336]

Hatcheries: The Government planned to build and operate a large hatchery to increase pl supplies. The Government has since revised those plans and currently operates only a small research hatchery.

Labor rebate: As part of its employment program the Panamanian Government in 1989 authorized growers to deduct small payments ($36 per month) for every worker from their land lease fees.[337]

Research: The Government created research centers which are conducting practical studies to assist growers. (See: "XVIII. Technical Capability: Research.")

Technical assistance: The Government offers some technical assistance to small and medium-sized growers. The authors have no assessment of the effectiveness of that assistance. Many farmers have criticized the Government, complaining that not only has it not adequately supported the industry, but that some of its policies have actually hindered development.

Electricity/fuel rates: Growers also complain that high fuel and electricity rates and taxes have hindered the industry's ability to compete effectively with shrimp culture operations in other countries.

Farm sizes: Land use concessions for the MIDA/IDB loan restricted the pond area of individual farms.[338] This has resulted in the construction of several small farms which may not be large enough to support profitable operations.

Feed industry: Government efforts to support domestic feed companies have impaired operations at some companies. Observers say that the Government's restrictive import regulations force growers to purchase what they claim are inferior local feeds at substantially higher prices than they would pay for imported feeds. (See "IX. Feed.") Agromarina had to cancel expansion plans in 1987, for example, because the Government prohibited feed imports.[339]

Import policy: Import restrictions impair operations at farms and hatcheries because of the complications in obtaining equipment and chemicals/drugs not produced domestically. The problem is especially disrupting for hatchery managers who may require items on extremely short notice.

Pl restrictions: Government restrictions designed to protect wild shrimp stocks have created problems for the growers. The 1988 regulations prohibiting the collection of wild pl made it difficult for many growers to stock their ponds. Previous restrictions on pl exports initially created problems for hatcheries interested in export markets.

Regulation: Many growers are concerned about the administration of current regulations. Some report the application process has taken up to 3 years and others say that they have never received responses to their applications.

Tax policy: Many farms are concerned about fees, land use charges, and taxes imposed by various government agencies.

Growers have requested that the Government more directly promote the shrimp culture industry. Industry representatives have requested a variety of actions to support the industry.[340]

Credits: Industry groups have requested government-subsidized credits. The Government has offered, however, no major program of subsidized credits since the BNP/IDB credit line was closed.[341] (See: "XVII. Credit.")

Electricity rate: The growers wanted a reduction in electricity rates.

Export subsidies: Growers requested that they be included in the Government's export tax credit (CAT) program for non-traditional exports. They claimed that the industry should qualify for the 25 percent CAT, because cultured shrimp was a non-traditional product.[342]

Fuel prices: Growers requested a special price for diesel fuel and pointed to the low fuel prices which have assisted the industry's development in Ecuador.

Import privileges: Growers and hatcheries would like duty-free import privileges.[343]

Land charges: Growers requested that land lease rates be sharply reduced, insisting that these high charges were a substantial burden. Many growers who were encountering substantial technical difficulties and, at best, reporting marginal earnings, saw these rates as a major Government action adversely affecting the industry. The growers suggested sharply reduced lease rates of $0.12 per hectare.

Pl supplies: Growers requested modification of regulations which inhibited their access to wild postlarvae. (See "XIV. Postlarvae Supplies: Wild Collection.")

Government officials are currently considering how to best assist the industry. Most officials believe that with the limited resources available they will be unable to initiate a major promotional program that would satisfy industry demands.[344] Some officials believe, however, that the Government can play a meaningful role. Activities currently under way, or being considered, include:

Credit: preparing feasibility studies to help investors obtain credit.

Evaluation: designing an evaluation system for farms.

Industry: promoting APAC and working closer with growers. Some observers believe that the limited role that APAC has played is indicative of a general reluctance of growers to work together to achieve common goals. DINAAC is attempting to promote expanded cooperation among industry participants. DINAAC organized the "II Congreso Nacional de Acuicultura" in 1991. The Congress gave industry, government, and academic groups an opportunity to discuss a variety of subjects related to the aquaculture industry and to consider future strategies.[345]

International assistance: helping to obtain assistance from foreign donor agencies.

Management: preparing a shrimp management plan to guarantee the maximum production of pl and establishing closed areas to protect wild stocks. Existing regulations need to be revised to conform to the findings of various scientific and technical studies.

Regulation: establishing a simplified process for obtaining land use authorizations.

Research: researching and publishing information on shrimp culture methods and obtaining industry financing for needed research that the Government cannot finance on its own.

XVI. LEGAL FRAMEWORK

A variety of Panamanian laws affect the shrimp culture industry. Laws and regulations govern land authorizations, water use, and taxes (municipal and national). The national Government in 1983 reportedly enacted a tax on shrimp growers of $6.00 per hectare. While the charge went in effect on January 1, 1984, most growers have refused to pay it and demand that it be canceled.[346] Municipal governments plan to add an additional tax of about

$1.10 per ha monthly.[347] The national Government also controls the area utilized for shrimp ponds by issuing permits and concessions. Decree-Law 25 (1966) mandates that water belongs to the public domain, and that its use and discharge is subject to Government approval.[348]

The authors have received conflicting reports on Government policy concerning the size of shrimp farms. Some observers report that the Government for a period restricted authorizations for shrimp farms to no more than 50 hectares.[349] This policy reportedly resulted in the construction of small, often uneconomical farms. Not only could these small investors not afford to contract technical advisors, but most were not large enough economic units to achieve production levels needed to sustain operations. As a result, many have reported unprofitable operations. Other observers, however, deny that the Panamanian Government ever restricted farms to 50 hectares.[350] Current Agriculture Director, Ing. Hugo Perez Athanasiades, reports that the Government in 1982 limited shrimp pond concessions to 200 ha as part of the MIDA/IDB project, but the limit has since been rescinded. Ing. Perez states authoritatively that, "At present the Government does not limit the size of shrimp pond concessions."[351]

The Panamanian Government has developed a detailed regulatory regime for shrimp. These regulations primarily affect the fishermen targeting wild stocks. New regulations were issued in 1990.[352] The regulations primarily concern the trawler fishermen, fixing the closed and restricted seasons and setting limits on certain fishing areas and trawl mesh. (See: "I. Capture Fishery.") Artisanal operations are also regulated, although enforcement is more difficult. The shrimp culture industry, however, is less directly affected. The major impact on growers is the restriction on the collection and a prohibition on the export of wild-caught pl and broodstock.

Industry groups complain about the current legal framework. Some criticize Panamanian laws which they charge do not adequately address the needs of the country's expanding aquaculture industry. Outdated regulations reportedly cause a variety of problems. One particularly serious difficulty is severe losses resulting from illicit harvests.[353] Growers have attempted to solve the problem by employing armed security guards and attaching weights to drainage outlets to make such unauthorized harvests difficult.[354] The dilemma, however, continues to concern many growers. Others object to the complicated legal process in obtaining Government permission to use state-owned land.

XVII. CREDIT

Panama has developed a major regional banking center. More than 100 banks from over 30 countries provide a wide range of banking and other financial services. Panamanian banks have been adversely affected by the regional debt crisis which began in 1982 and restricted economic activity in several Latin American countries with heavy debt burdens. The disruptions associated with the Noriega regime after 1987, U.S. sanctions, and the resulting downturn have seriously impaired economic activity in Panama. The country's banking system was especially disrupted by the U.S.-imposed sanctions; deposits dropped from $41 billion to less than $12 billion by the end of 1989. Growers found it extremely difficult to obtain credit in the deteriorating economic environment because investors were unwilling to make major new commitments.

The arrest of General Noriega in 1989 radically changed the country's economic outlook. The new democratically elected Government is working hard to promote economic growth, primarily by encouraging the private sector.[355] (See: "IV. Economic Conditions.") The banking system appears to be recovering strongly. Deposits increased by $3.6 billion in 1990. All banking restrictions imposed due to the problems associated with the Noriega regime were ended in June 1990.

The Panamanian Government has provided some financing to the shrimp culture industry. These loan programs played an important role in the industry's beginning phase. The construction and expansion of several individual farms were financed through state banks.

COFINA has financed the construction of 1,500 ha of ponds. Many of the farms involved, however, were unsuccessful and eventually had to be closed.[356]

The **Banco Nacional de Panama** (BANCONAL/ BNP) obtained some funds from the IDB for aquaculture loans (See: "XV. Government Policy.").[357]

The Panamanian Government currently has no special credit program for shrimp growers and is unlikely to initiate any major credit scheme in the near future. The Government already faces a substantial debt load and has been pursuing a tight fiscal policy to reduce Government deficits and stabilize public-sector debt.[358] The Panamanian Government's ability to borrow is limited by the massive arrears inherited from the previous regime. In addition, the use of the U.S. dollar makes it impossible to simply print money as some Latin American Governments have done.

Growers are currently dependent on the country's commercial credit system for loan capital. Growers have been building about 300 ha of ponds annually since 1988 (appendix E1).[359] (See: "V. Area/Location" for details on pond construction.) Industry sources complain, however, that the shortage and difficulty in obtaining credit has been a major impediment to the industry's expansion. The new farm and hatchery projects reported in 1991 suggest that some growers were unable to obtain credit. The authors have no data, however, describing the current availability of credit.

Panama is attempting to attract foreign credit. The Government approved three laws in 1986 designed to streamline the economy and attract foreign investment.[360] The country has offered industrial zone facilities, special tax exemptions, and liberalization of the labor code. Government officials have identified several sectors as offering ideal investment opportunities, one of which is aquaculture.[361] Potential investors have access to the Panamanian Trade Development Institute (IPCE) which provides information and project expediting services. Unlike most Latin American countries, the Government makes few practical distinctions between foreign and domestic investors.

XVIII. TECHNICAL CAPABILITY

The development of a technically sophisticated new industry poses difficulties for a small country like Panama with a limited technical base. The Panamanian Government has attempted to aid the industry, but with limited resources and achieving mixed results.

A. Research

Panamanian shrimp growers, as is true of growers throughout Latin America, would greatly benefit from an effective research program. Research on many basic subjects is needed. One observer identified practical work to determine the best pond management practices as the greatest priority. One local official points out that some work has been done.[362] The Panamanian Government has sponsored important studies on shrimp culture. While the research effort has been limited, it is one of the largest and most sophisticated efforts of its kind in Central America. **DINAAC** has conducted a variety of studies on freshwater shrimp, including filtration and recirculation of water in growout ponds, feed formulas using local ingredients, polyculture (freshwater shrimp with tilapia and carp), growout strategies (especially densities), and other subjects.[363] The MIDA/IDB fisheries development project helped to increase the Government's ability to support the shrimp culture industry. The IDB loan financed the completion of the Estación Experimental de Aguas Estuarinas/Salobres (EEAS) Ing. Enrique Enseñat and the Estación de Maricultura del Pacífico (EMP). These two DINAAC research centers are the primary Government facilities currently conducting marine shrimp culture research in Panama:

Experimental de Aguas Estuarinas/Salobres (EEAE): The EEAE Ing. Enrique Enseñat Center was built in 1982 at Aguadulce, Coclé, about 25 km from Panama City. The new facilities at the Center enabled the Panamanian Government to initiate its own shrimp culture research program.[364] Phase One at the Center consisted of 42 small ponds (0.06 ha each), a reservoir of 0.4 ha, and two hydraulic pumps, each with a capacity of 23,000 liters (l) per minute. Phase Two consisted of 10 ponds (0.5 ha each), a reservoir canal, and a hydraulic pump with the capacity of 32,000 l per minute. EEAE researchers have focused on better understanding pond dynamics.[365] Different growout strategies are assessed in the small Phase One ponds. Those strategies that appear to be particularly promising are then used for trial runs in the larger Phase Two ponds. Researchers at EEAE have focused primarily on practical subjects of greatest concern to growers, such as water exchange rates, feed formulas (especially protein content), stocking density, pond dynamics, hatchery and wild pl comparisons, and polyculture (with tilapia). The Center is equipped with a conference room, water analysis lab, computer center, dormitories, processing plant, feed warehouse, tool shed, and a meteorological station.[366]

Estación de Maricultura del Pacífico (EMP): The center was built in 1982, close to the Vacamonte fishing port. The initial cost was $140,000, much of which was provided by the Taiwan Government. The EMP facilities include living quarters, algae culture room, hatchery (Taiwan technology), section for raising larvae and *Artemia*, 18 concrete tanks to store water, and small nursery and broodstock ponds. Research at the center focuses on mariculture, especially *Penaeid* shrimp culture, but some work has also been done on freshwater shrimp. Studies have addressed nutrition and algae and zooplankton culture. Some work has also been conducted on other species, including crabs, oysters, and scallops.

A variety of other groups have also conducted some research. Non-governmental research on shrimp culture has been primarily conducted at the individual farms. Few details are available on this research as it is maintained as proprietary information by the companies concerned. Panamanian academic institutions appear to have conducted little research on shrimp culture. The country's most important university, the **University of Panama**, has done some oceanography and fisheries research, but information on shrimp culture work is unavailable.[367] One foundation, the **Fundacion Shinkichi Matsufuji** (FSM), has done some work on shrimp. One of their major projects has been an effort to increase wild shrimp stocks through restocking. FSM, in association with DINAAC, has reportedly conducted four restocking efforts to increase wild stocks. One such effort was conducted February 1, 1991, when 15 million *Penaeus sp.* juveniles were released.[368] Another private group, **Laboratorio Gorgas**, has reportedly done some work on shrimp diseases.[369]

B. Training/technical services

The Government provides some technical assistance in aquaculture. DINAAC operates substations in several provinces to study marine culture and maintains the EMP lab at the Port of Vacamonte to study shrimp reproduction and train biologists. DINAAC has provided extension services to 24 farms.[370] DINAAC is playing a major role in the training of Panamanian and other Latin American aquaculture specialists. As of early 1991, the agency had trained 144 Panamanians and 48 foreigners in freshwater shrimp culture and 95 Panamanians and 148 foreigners in marine shrimp culture. Graduates of the program are currently employed by shrimp farms throughout Central and South America.[371]

The Government has organized shrimp culture seminars to help disseminate technical information to growers. The second of these seminars, Encuentro Nacional de Productores de Camarones, was held January 31, 1991, at the EEAE Aguadulce facility. The seminar consisted of eight committees on various subjects followed by a question and answer session. Most of the important growers reportedly attended.[372]

One observer has identified extension services as one of the industry's greatest needs.[373] The Panamanian Government offers some extension services through EEAE, EMP, and the smaller Divisa and Gualaca Stations.[374] The extension program is aimed primarily at small-scale growers. The Government estimates that it has assisted several freshwater growers (operating approximately 425 ponds) and 24 marine shrimp growers.[375] DINAAC has helped the growers select sites, design ponds, and chose the most favorable growout system. It is difficult to assess the extension program, but a substantial portion of the Panamanian technicians currently employed by the industry has benefitted from it. Nevertheless growers complain that DINAAC does not have adequate resources to conduct needed research or provide adequate extension services.

Private consulting services are also available to Panamanian growers (appendix A). Mariculture Management Services (MMS) has advertised in various journals.[376] The authors have no information, however, on the range of services offered.[377] MMS has reportedly provided technical services to several farms and hatcheries.

XIX. FOREIGN ASSISTANCE

A variety of foreign countries and international organizations are assisting Panama in developing its shrimp culture industry. The principal foreign role has been played by private U.S. technicians and investors. Only a few firms, however, have contracted for foreign technical assistance. Other foreign groups have played a relatively modest role in the industry's development. One multinational organization (IDB) sponsored an important development project and other multilateral groups (OLDEPESCA/EC) are currently sponsoring a regional project. Major foreign participation has included:

Canada: The Canadian International Development Research Center (IDRC) has provided some funding for Government research centers.[378]

European Community: Panama participates in a Central American regional fishery development program (ALA REG 9009). The overall program totals ECU 13.4 million.[379] The 4-year (1991-95) Programa Regional de Apoyo al Desarrollo de la Pesca (PRADEPESCA), is a regional fisheries development project. PRADEPESCA has an aquaculture project which includes marine and freshwater shrimp hatchery and grow-out work. PRADEPESCA is also designed to strengthen the individual country fishery agencies and to help encourage training programs. The program is partially financed by the EC and coordinated by the Organizacion Latinoamericana para el Desarrollo Pesquero (OLDEPESCA).[380]

FAO: FAO has helped organize workshops in Panama. A 3-day workshop, "Socioeconomic Impacts of Penaeid Shrimp Culture," was held in 1988.[381]

France: The French state-consulting group, France-Aquaculture, has done some work in Panama. A mission headed by Dr. Alaín Michel and Dr. Jacques Calvas from the France Aquaculture Pacific Oceanographic Center in Tahiti reportedly visited Panama, but the authors have no details on their activities. France-Aquaculture was awarded a contract to build a hatchery as part of the MIDA/IDB project,[382] but the hatchery was never built. Details on the cancellation are unavailable.

Inter-American Development Bank (IDB): The IDB fisheries development project initiated in 1982 has been the most significant foreign assistance project conducted in Panama to assist the fishing industry. (For details on the project see "XV. Government Policy.")

OLDEPESCA: See EC.

Organization of American States: The OAS was reportedly considering a shrimp culture project as part of its Marine Sciences Program, but no details are available on the results.

Spain: The Spanish Government has provided some assistance through Subproject Two (Aquaculture) of the Programa Iberoamericano de la Ciencia y Tecnolgía para el Desarrollo y Centenario (CYTED-D).

Sweden: The Swedish International Foundation for Science has provided some funding for Government research centers.[383]

Taiwan: The Taiwan Aid Mission supports a project headed by Dr. Huan Ting Lang. The Taiwan group trained Panamanian biologists in freshwater shrimp reproduction during 1981 at the old CAMARPAN facilities.[384] The Mission also provided $0.1 million in financial assistance in the construction of EMP.[385] Taiwan has continued to support a small freshwater shrimp project as part of its larger agriculture assistance program. The Taiwan program supports 1-2 technicians and has also provided some equipment.[386]

United States: Private U.S. investors and technical consultants have played a major role in the industry's development, providing both equity capital and access to the latest technical innovations. The Agromarina farm and hatchery has been one of the industry leaders, not only in Panama, but throughout Latin America. It was founded by Ralston Purina, but is currently owned by another U.S. company, Grenada. Various U.S. consulting groups have also been active in Panama. RPI, for example, conducted a training course in 1987.[387] MMS has reportedly played an important role at several farms and hatcheries. U.S. Government assistance has been limited primarily to freshwater finfish aquaculture. The U.S. Agency for International Development (AID) has sponsored some technical exchanges with Auburn University and other academic institutions which have benefitted Government research centers.

XX. OUTLOOK

The Panamanian shrimp culture industry benefits from some favorable growing and economic conditions, although growers have experienced a variety of problems. Growers in several other countries are achieving somewhat better yields and reporting lower production costs. Sites exist for a small industry, although the country's full potential is unknown given the lack of a detailed coastal survey. Agromarina and Aquachame have demonstrated that shrimp can be commercially cultured in Panama, but growers may not be able to achieve yields as high as those reported in some other Latin American countries. The industry's failure to rapidly expand appears to be due to a combination of poor management practices at existing farms, the chaotic economic situation in the late 1980s, and some less-than-favorable growing conditions, especially the protracted dry season. Some observers are optimistic about the industry's future, believing that the fall of the Noriega Government is creating a more favorable economic climate. Other observers, however, are much more pessimistic. The authors cannot yet verify, however, any major positive impact on the shrimp culture industry. Some report that many companies continue to experience financial problems. Many industry groups were anticipating a much better harvest in 1991 than has been reported. As a result, the industry's future is unclear.

Local observers report a variety of problems which are impeding the shrimp culture industry's development.

Administration: Growers report problems in completing the complicated and time-consuming process of obtaining official authorization ("concesiónes") to use land for shrimp ponds.

Area: Some observers report that substantial areas exist which could be developed for shrimp ponds. Others say that the industry appears to have relatively limited potential for expansion. Many of the best sites have already been developed in the current centers such as Aguadulce, but additional sites probably can be found in other areas. Construction and operating costs may prove higher in these new areas which are lightly settled and have more limited infrastructure.

Credit: Obtaining adequate credit remains a major difficulty for potential growers. Not only are loans hard to obtain, but they are available only at high interest rates.

Electricity/fuel prices: Some industry groups believe that relatively high fuel and electricity prices are a major problem for Panamanian growers.

Feed: Growers complain of poor quality and high feed costs. Feed companies, however, reject those charges.

Industry cooperation: The lack of cooperation among growers has hindered the industry's ability to address major common problems. Many growers are reluctant to release information on their operations and share insights with each other. As a result, serious coordinated efforts to sponsor research and marketing efforts through industry groups like APAC have not proven feasible.

Instability: The credit problem was exacerbated by the political and economic instability associated with the Noriega regime. The arrest of General Noriega in 1989 is allowing a democratically-elected Government to restore normal economic activity and could prove beneficial to the industry.

Legal framework: The lack of a law addressing the aquaculture industry is a serious concern to growers. Industry sources mention a variety of problems, including thefts from the farms, complications associated with export shipments of pl and nauplii, and the lack of any promotional program.

Research\Training: Only limited research results have been published. Growers complain that DINAAC does not have adequate resources to conduct needed research or provide adequate extension services. Panamanian academic institutions do not currently offer any specialized shrimp culture training programs, although DINAAC has conducted a training program for both Panamanian and foreign personnel.

Seedstock: Some observers complain that the natural availability of seedstock is declining, making Panamanian growers increasingly dependent on hatcheries. Others insist that inefficient collecting methods are not making full use of the available resource. Hatcheries have been able to produce pl for the expanding pond area, but many growers refuse to buy the higher-priced hatchery postlarvae.

Projecting future Panamanian harvests at this time is difficult, given the conflicting information available. The industry has reported a variety of problems. Despite Government promotional efforts, many of these problems have been caused or exacerbated by Government economic and social policies. There also appears to be some physical constraints, although the precise cause of the problems is not well understood. The annual dry season which impairs operations at many farms appears to be a major impediment. A few successful farms have proven that shrimp can be profitably cultured, although yields may be somewhat below those achieved in other Central American countries. While the low yields do not appear to be significant enough to preclude the industry's development in Panama, they are clearly impairing the industry's expansion. The increasing experience and technical competence of Panamanian growers suggest that the industry will report some, but probably unspectacular, expansion during the 1990s. Panama's small area limits the industry, but harvests of 10,000 t by the year 2000 may be possible if some of the major problems faced by growers are successfully addressed. Given the difficulties experienced in resolving these problems to date, however, more modest projections of about 5,000 t may be more realistic. The potential for a small, but profitable industry appears to exist in Panama, although some are convinced that the hatchery industry will out-perform growout operations.

Panama is emerging as a major source of seedstock for Latin American growers. Several observers are projecting an especially optimistic outlook for the country's expanding hatchery industry. The hatcheries currently appear to be out-performing growout operations. The Panamanian hatchery industry will probably continue expanding during the 1990s. Some hatcheries reported marketing difficulties during 1991 as a result of the 1991-92 El Niño event. Agromarina reported marketing difficulties in 1991 because of the increased availability of wild pl and increasing competition from Ecuadorean hatcheries. The company has adopted a new marketing strategy for 1992, but demand and price levels are still unknown. PLC has reported more favorable 1991 results. Some observers are convinced that Panama will emerge as a major source of seedstock for Caribbean, Central American, and Atlantic-coast South American growers. The market appears particularly promising in the many Caribbean/Atlantic coast countries that have the potential to culture shrimp, but lack an indigenous species suitable for pond culture. Panamanian observers are hopeful that high pl demand in these expanding shrimp culture industries should create a strong demand for Panamanian pl and nauplii during the 1990s.

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ENDNOTES

SECTION I. (Capture Fishery)

1. The Dirección General de Recursos Marinos (DIGEREMA) reported a fleet of 261 trawlers in 1989 and 1990. Some industry sources say the actual number is higher. DIGEREMA had been trying to reduce the fleet through attrition, but General Noriega ordered the issuance of new licenses. U.S. Embassy, Panama City, October 3, 1990 and October 26, 1991.

2. U.S. Embassy, Panama City, January 17, 1991.

3. The map shows the location of each Panamanian Province.

4. U.S. Embassy, Panama City, January 17, 1991.

5. Charles Oravitz, NMFS, unpublished trip report, April 11, 1986.

6. "Panama: Business Continues Despite Political Turmoil," *The Fish Boat*, August 1988, pp. 25, 39-41.

7. Victor Nishio, personal communications, November 5, 1991.

8. U.S. Embassy, Panama City, October 3, 1990.

9. Sjef Van Eys, INFOPESCA, personal communications, May 9, 1991.

10. "Panama: La Reactivacion del Pais Aun no Llega a la Pesca," *INFOPESCA Noticias Comerciales*, August 20, 1990.

11. U.S. Embassy, Panama City, December 4, 1990 and October 26, 1991.

12. Wild catch estimates range from 4,000-5,100 t (appendix D2 and D5). The reason for this discrepancy is unexplained, but both sources reveal a substantial decline in 1990.

13. U.S. Embassy, Panama, July 25, 1991.

14. U.S. Embassy, Panama City, October 26, 1991.

15. David G. Hughes, "The Marine Shrimp Culture Industry in Panama," *Proceedings of the World Shrimp Market Conference*, November 29-December 2, 1984, pp. 167-175.

16. Fisheries and aquaculture are administered by two different agencies in Panama. DIGEREMA is the Panamanian fisheries agency and is administratively under the Ministerio de Comercio y Industrias (MICI). The Dirección Nacional de Acuicultura (DINAAC), however, is under the Ministerio de Desarrollo Agropecuario (MIDA).

17. DIGEREMA, "Documento presentado en la III Reunión Ordinaria del Grupo de Trabajo de Investigación Pesquera (OLDEPESCA), 1990.

18. U.S. Embassy, Panama City, July 25, 1991.

19. Nishio, *op. cit.*, November 5, 1991.

20. U.S. Embassy, Panama City, October 26, 1991.

21. Officials believe there may be some opportunities for squid or tuna fishing. Estimates for converting the vessels range from $1,000 to $50,000, depending on the type of vessel. U.S. Embassy, Panama City, October 26, 1991.

22. U.S. Embassy, Panama City, October 3, 1990 and October 26, 1991.

23. The Government now restricts the length of gillnet per fisherman. Van Eys, *op. cit.*

24. Bogdan Kwiecinski and Belgis Chial, "El Fenomeno de el Niño y la Pesca de Camaron en Panama," *CPPS Boletín ERFEN*, No. 29, 1989, pp. 27-30 and Maugle, "Present Situation," *op. cit.*, pp. 2-3.

25. Hermes Sucre Serrano, "Drásticas bajas en pescas de mariscos," *Estrella de Panama*, September 21, 1988; Victor Nisio, personal communications, December 30, 1988 and November 5, 1991; and Sjef van Eys, INFOPESCA, personal communications, September 3, 1990.

26. The primary cause of the decline has been lower trawler catches, although expanding shipments to Europe have also reduced U.S. shipments slightly. Even so, if the real value (after inflation) of exports is calculated, export earnings since 1986 declined much more than 50 percent.

27. "Panama: Business Continues Despite Political Turmoil," *op. cit.*

28. See for example INFOPESCA, "Panama: La reactivacion del pais aun no llega a la pesca," *INFOPESCA Noticias Comerciales*, August 20, 1990.

29. INFOPESCA, "Panama: La Reactivacion," *op. cit.*

30. Nishio, *op. cit.*, November 5, 1991.

31. Since 1975 the Government has prohibited the sales and construction of new shrimp trawlers. U.S. Embassy, Panama City, October 26, 1991.

32. U.S. Embassy, Panama City, October 3, 1990.

33. Regulations include limits on the minimum trawl mesh size (3 in) and the overall size of the nets used by artisanal fishermen, a reduction in the number of trawling days in November, December, and January to 16 days (in addition to the closed season in February, March, and April), a reduction in the catch limit when a specified percentage of the shrimp catch is juveniles which are not sexually mature (under 26/30 count) white shrimp , the prohibition of shrimping in certain areas, and a prohibition on the exportation of wild-caught pl and gravid females. INFOPESCA, January 20, 1991 and U.S. Embassy, Panama City, December 4, 1990. Some industry and Government observers believe that the new regulations will be difficult to enforce, especially the limitation on catches of juvenile white shrimp.

34. The 1991 closed season was January 20-March 20 and fishing was limited during certain months: October (18 days), November (16 days), December (16 days), and January (16 days). Decreto Ejecutivo No. 41, October 4, 1991.

35. The SMP's main arguments were the need for further studies and the fishermen's decision not to joint the work stoppages organized by the anti-Noriega opposition. The fishermen also expressed concern with artisanal fishing.

SECTION II. (Aquaculture Industry)

36. A good description of the program is available in Richard Pretto Malca, "Consideraciones en torno a la agroacuicultura en Panama," in *Memorias Segunda Reunion Red Nacional de Acuicultura*, COLCIENCIA: Bogota, January 1989, pp. 33-61.

37. FAO, "Aquaculture Production, 1986-1989," *FAO Fisheries Circular*, No. 815, Rev. 3. Information explaining the decline is unavailable.

SECTION III. (Growing Conditions)

38. Rouse, *op. cit.* and Eric Gonzalez, Vice President, Asociación Panameña de Acucultores, personal communications, July 29, 1991.

39. Various observers have estimated that mangroves cover 360,000-500,000 ha in Panama. MACI-FAO, "Ubicacion actual de los bosques de Panama," Proyecto de inventario y demonstracion forestal, 1969 and Letorneau and Dixon, 1982 as cited in Paul Maugle, "Present Status and Future Potential of Shrimp Mariculture in Panama," report prepared for the U.S. Agency for International Development, September 1986, p. 7.

40. David G. Hughes, Azael Torres Diaz, Ronald P. Phelps, and Richard Pretto Malca, "Aguadulce, Panama: Cycle I of the Global experiment," *Pond Dynamics/Aquaculture Collaborative Research Data Reports*, Vol. VIII, No. 1, June 18, 1991, Oregon State University.

41. Maugle, personal communications, *op. cit.*, July 23, 1991.

42. Hughes, *et. al.*, "Aguadulce," p.3.

43. Maugle, "Present Status," *op. cit.*, p.7.

44. Maugle, "Present Status," *op. cit.*, p.7.

45. James McVey, unpublished trip report, April 14, 1980.

46. Dr. Paul Maugle, PDM & Associates, personal communications, July 23, 1991.

47. One researcher at the University of Panama has done some work, but a copy was not available to the authors. V. Quiroz, "Efectos de varios niveles de recambio de agua a la calidad de agua y en la produccion de *Penaeus vannamei* en estanques de tierra," Licenciatura thesis in biology, in preparation, 1990, University of Panama.

48. Dr. David Rouse, Auburn University, personal communications, *op. cit.*, July 25, 1991.

49. The CRSP is conducted under the authority of Title XII of the International Development and Food Assistance Act of 1975. The Pond Dynamics/Aquaculture series is one of several agricultural CRSPs supported by AID. The series includes detailed data on conditions at the Ing. Enrique Enseñat Brackishwater Experiment Station at Aguadulce. See Hughes, *et.al.*, "Aguadulce," *op. cit.* A similar study at a freshwater facility was conducted at the Gualaca Freshwater Aquaculture Research Station. David R. Teichert-Coddington, Medardo Peralta, Ronald P. Phelps, and Richard Pretto Malca, "Gualaca, Panama: Cycle I of the Global Experiment," *Pond Dynamics/Aquaculture Collaborative Research Data Reports*, Vol. VII, No. 1, April 15, 1991, 97 p.

SECTION IV. (Economic Conditions)

50. For details on problems faced by one country with a weak currency and inflation problem, see Tom Revord and Dennis Weidner, "Peruvian Shrimp Culture," *International Fishery Reports*, (IFR-91/91), December 6, 1991.

51. U.S. Embassy, Panama City, "Investment Climate Statement" March 28, 1991.

52. U.S. Embassy, September 13, 1991.

53. U.S. embassy, *op. cit.*, March 28 and September 13, 1991.

SECTION V. (Area/Location)

54. Many of the best sites in the more accessible areas may have been already developed. Rouse, personal communications, *op. cit.*, July 25, 1991.

55. Lic. Vielka Morales de Ruiz, Jefa de la Estación de Maricultura del Pacifíco, provided by Luis Dorati, *Caribbean Fishing Agency*, personal communications, July 12, 1990.

56. *Infofish Trade News*, 12/88, July 20, 1988 and Consejo Nacional de Inversiones, "Sector Economicos con Posibilidades de Generar Nuevas Inversiones en Panama," unpublished study, Panama, August 10, 1987.

57. Ing. Armando Martinez, former Director of Recursos Marinos, Ministerio de Comercio y Industrias, quoted by Rosalina Orocu Mojica, "Camarones extranjeros saturan el mercado," *La Republica*, February 13, 1985.

58. Eric Gonzalez, Agromarina and ASAP Vice President, personal communications, August 8, 1991.

59. The author was serving as an aquaculture research advisor to the Panamanian Government. David G. Hughes, "Aquaculture: Central America," *Proceedings of the World Shrimp Market Conference*, November 29-December 2, 1984, pp. 162-166.

60. Hughes, "Aquaculture," *op. cit.*, p.165.

61. Enid Raquel Rivera Quintero, "Culture of *Penaeus* shrimp in the Republic of Panama," *INFOFISH International* (3/89), pp. 36-38.

62. Morales de Ruiz, *op. cit.*

63. Bob Rosenberry, "Shrimp Farming in the Western Hemisphere" June 1990.

64. Maugle, "Present Status," *op. cit.*, p.7.

65. Departamento de Programación y Evaluación, DINAAC, MIDA, Panamá, 1991. As cited in DINAAC.

66. "Problems for Panama Shrimp Farmers," *Fish Farming International*, March 1991.

67. It is not immediately apparent which observer is more accurate. Considerable differences exist between the two appendices, but much of the conflicting data is for the small marginal farms. The only significant difference concerning a major farm is that H1 lists a much smaller area for Acuachame than H2, suggesting that H2 is a slightly more current data set.

68. One industry source estimates 4,200 hectares. More, *op. cit.*, January 7, 1992. A Government source estimates 4,500 hectares. Ing. Hamed L. Tuñón, Subdirector, Dirección Nacional de Acuicultura, personal communications, January 14, 1992.

69. The precise size of the new farm is not known. The authors have received reports varying from 800-1,400 hectares.

70. Jorge Pang, Agromarina, personal communications, May 27, 1991.

71. Gonzalez, *op. cit.*, August 8, 1991.

72. Nishio, *op. cit.*, November 5, 1991.

SECTION VI. (Species)

73. For a glossary of shrimp species occurring off Panama, see appendix B.

74. Nishio, *op. cit.*, November 5, 1991.

75. For more details on specific species see Dennis Weidner, Tom Revord, and Randolf Wells, "Latin American Shrimp Culture, 1990-2000," *International Fishery Report, in press.*

76. One researcher compared *P. vannamei* and *P. stylirostris* results when cultured separately and together. He found that there was no difference in the expected performance of each species when the two were cultured together in the same pond. He found that *P. vannamei* tended to grow about twice as fast in nursery ponds as *P. stylirostris* in both ponds where supplemental feeding was applied and where it was not. Ivonne Rodriguez, "Feeding *Penaeus vannamei* and *Penaeus stylirostris* in Nursery Ponds," *ICA Communicae* (Auburn University International Center for Aquaculture Newsletter), Vol. 2, No. 1-2, December 1988, p. 17.

77. One observer reports that *P. vannamei* is only a minor species off Panama. Maugle, personal communications, *op. cit.*, July 23, 1991.

78. For details on one published study of mixed runs see A. Torres, "Produccion de *Penaeus stylirostris* bajo la influencia del *Penaeus vannamei*, en estanques experimentales de agua salobre con y sin alimentacion durante la epoca seca," presented to the First National Scientific Congress, University of Panama, Panama, December 1984.

79. "Hampered Potential," *INFOFISH International*, May 1988, p.12.

80. Rivera, *op. cit.*, p.37.

81. Rivera, *op. cit.*, p.37.

82. Hamed L. Tuñón, DINAAC Deputy Director, "Situacion Actual del Cultivo de Camarones en Panama," *Simposio Centroamericano Sobre Camaron Cultivado*, Honduras, April 24-26, 1991, p. 13.

83. Dirección Nacional de Acuicultura (DINAAC), Ministerio de Desarrollo Agropecuario, *Manual de cria de camarones peneidos en estaques de aguas salobres*, Panama, 1984.

84. David B. Rouse, "Identification of Key Issues to be Addressed in Future Research for Marine Shrimp Culture in Panama," AU/AID Program Support Grant DAN 5058-G-SS-6073, October 1986.

SECTION VII. (Methods)

85. Salt flat sites are reportedly only suitable for extensive operations. FAO report cited in "Problems for Panama Shrimp Farmers," *op. cit.*

86. For details on the impact of the dry season on pond operations see D.G. Hughes, G. de Gomez, E. Lasso de la Vega, R.P. Phelps, and R. Pretto Malca, "Rainy and dry season comparisons in *Penaeus vannamei* production ponds in Panama receiving various water exchange rates: water quality variation," Poster session at the World Aquaculture Society Meeting, Guayaquil, Ecuador, January 1987.

87. Paul Maugle, "Post Larvae Shrimp Mortality Reduction Study," *Artemia Newsletter*, May 1988.

88. Gonzalez, *op. cit.*, August 8, 1991.

89. Maugle, personal communications, *op. cit.*, July 23, 1991.

90. Sjef van Eys, INFOPESCA Director, reports that he is initiating a project with MIDA to use the fish and crabs harvested incidentally by shrimp farmers. Preliminary research suggests that substantial quantities are involved. Van Eys, personal communications, *op. cit.*, August 6, 1991.

91. Revord and Weidner, "Ecuadorean Shrimp Culture," *International Fisheries Report*, (IFR-92/19), February 28, 1992.

92. Weidner and Revord, "Colombian Shrimp Culture," *International Fishery Report*, (IFR-91/90), December 15, 1991.

93. Growers in other Central American countries as well as Colombia also report difficulties during the dry season.

94. Gonzalez *op. cit.*, August 8, 1991.

95. Gonzalez, *op. cit.*, August 8, 1991.

96. Rivera, *op. cit.* p. 37.

97. Rouse, *op. cit.*

98. The following details on freshwater culture methods are abstracted from Tuñón, "Situacion Actual," *op. cit.*, pp. 5-12.

99. R. Pretto, G. Garson, V. Batista, and M. de Leon, "Estudio preliminar del policultivo de *Penidos* con peces nativos de aguas salobres," presented by R. Pretto to the Fifth Symposium of Latin American Aquaculture, University Austral de Chile, Valdivia, Chile, September 1983. A. Serrano, "Economics of tilapia production in monoculture or in polyculture with prawns, and utilizing manure or a commercial pellet as the nutrient input in Gualaca, Panama," Auburn University masters thesis, 1987. D.R. Teichert-Coddington, D.B. Rouse, A. Khater, and R.O. Smitherman, "Effects of two rates of organic fertilization and two levels of alkalinity on prawn production in a prawn-tilapia polyculture," paper presented at the World Aquaculture Society Meeting, Guayaquil, Ecuador, 1987. D.R. Teichert-Coddington, M. Peralta, and R. Pretto, "Prawn and tilapia culture in Panama: commercialization of freshwater aquaculture," paper submitted to INFOFISH, 1986. One researcher has prepared a marketing study, M.J. Perez, "Economic and marketing study of fish and shrimp in polyculture systems in freshwater ponds at Gualaca, Chiriqui Province," Auburn University Masters thesis, 1985.

SECTION VIII. (Yields/Production Costs)

100. One author attempted to evaluate various alternative management strategies to assess income, profitability and risk. U. Hatch, S. Sindelar, D. Rouse, and H. Perez, "Demonstrating the use of risk programming for aquaculture farm management: the case of *Penaeid* shrimp in Panama," *Journal of the World Aquaculture Society*, 1987, Vol. 18, No. 4, pp. 260-69.

101. Tuñón, "Situacion Actual," *op. cit.*, pp. 19-20.

102. Gonzalez, *op. cit.*, August 8, 1991.

103. One excellent study which assessed yields during the dry and rainy season is Hughes, *et. al.*, "Aguadulce," *op. cit.*

104. Tuñón, "Situacion Actual," *op. cit.*, pp. 18-19. Other good, but more dated descriptions are available. David Hughes. Hughes, "Marine," *op. cit.*, pp. 172-173 and Rivera, *op.cit.*, p. 37.

105. Rivera, *op. cit.*, p. 37.

106. Based on crops of from 0.5-0.7 t per ha and an average of about 2.5 harvests per year. Tuñón, "Situacion Actual," *op. cit.*, pp. 19-20.

107. Gonzalez, *op. cit.*, January 15, 1992.

108. Tuñón, "Situacion Actual," *op. cit., p. 11.*

109. Various observers have noted the somewhat lower Panamanian yields, but no industry consensus has emerged on the causes. Rouse, personal communications. *op. cit.*, July 25, 1991.

110. Agromarina for example reports crops of about 0.7 t per ha during the rainy season, but only 0.4 t during the dry season. The size of shrimp harvested also declines during the dry season. Gonzalez, *op. cit.* Another observer in an older report also notes lower yields during the dry season, but reports only a small differential. Rouse, "Identification," *op. cit.*, p.8.

111. Gonzalez, *op. cit.*, August 8, 1991.

112. E.W. McCoy, "Feasibility of pond culture of shrimp in Panama" Report to the National Directorate of Aquaculture, Auburn University, 1979.

113. U.S. Embassy, Panama City, May 29, 1984.

114. Consejo Nacional de Inversiones, *op. cit.*

115. Van Eys, *op. cit.*, May 9, 1991.

116. Sjef Van Eys, INFOPESCA, personal communications, January 10, 1992.

SECTION IX. (Feed)

117. For details on organisms present in the ponds see I. Quesada, "Ocurrencia de organismos bentonicos en estanques no alimentados sembrados con *Penaeus vannamei* durante la estacion seca," Licenciatura thesis in biology, in preparation 1990, University of Panama and E. Lasso de la Vega and M. Villareal, "Variacion de zooplancton en estanques de cria de camarones blanco durante la estacion seca," Presented to the Second National Scientific Congress, University of Panama, November 1985.

118. For details on the use of inorganic fertilizer, see A. de Leon, "El efecto de aplicar fertilizantes inorganicos en la producción de *Penaeus vannamei* en estanques," paper presented to the Second National Scientific Congress, University of Panama, November 1985. Also see Teichert-Coddington, *et. al.*, "Effects of Two Rates," *op. cit.*

119. Rivera, *op. cit.*, p. 37. See also D. Lore, H. Tuñón, and R. Visuetti, "Efecto de la aplicacion de abonos organicos concentrados y pescado fresco (*Dormitador latifrons*) en la produccion de *Penaeus stylirostris y Penaeus vannamei*," presented by H. Tuñón to the First National Scientific Conference, University of Panama, December 1984.

120. Rouse, "Identification," *op. cit.*, p.5.

121. Rivera, *op. cit.*, p. 37.

122. Maugle reports that Panamanian fishmeal is produced by shallow-water species which do not produce such high quality meal. The fatty acids, in particular, are different. The intensive agriculture practiced in Panama results in a growing runoff of agricultural chemicals which enters the food chain and residues are present in the domestically produced fishmeal. Maugle, personal communications, *op. cit.*, July 23, 1991. Another observer

is concerned with not only the fish species, but the handling of the catch, which impairs the quality of the meal produced. Cliff Reese, Zigler Brothers, personal communications, August 2, 1991

123. Tuñón, "Situacion Actual," *op. cit.* pp. 21-22.

124. Alberto Villageliu, Executive Vice President, Companía Azucera Estrella (CAE), personal communication, January 8, 1992. CAE is part of a financial group which owns the COMACO farm.

125. Tom Zeigler reports that NASA is turning out large quantities of high quality feed. Tom Zeigler, Zeigler Brothers, item 12.10.32, *Aquaculture Digest*, October 1987.

126. Alberto Paz Rodrigues, Executive Director, Nutricion Animal, personal communications, July 29, 1991.

127. España, *op. cit.*

128. For details on results with different protein contents see D. Teichert-Coddington and M. Arrue, "Efectos de dietas de proteinas y densidades de siembra sobre la producción de *Penaeus vannamei* en estanques de Herrera," *Revista Lst. Acui.*, 1988, Vol. 35, pp. 29-33

129. Reese, *op. cit.*

130. Gonzalez, *op. cit.*, August 8, 1991.

131. Rouse, "Identification," *op. cit.*, p.6.

132. Hughes, "Marine," *op. cit.*, p. 175.

133. Agromarina is reportedly interested in Peruvian (Nicoteca) and Colombian (Purina and Raza) feeds. Agromarina reports that it is trying to obtain special permission from the Government for such imports. Gonzalez, *op. cit.* Some limited information on the feed industry in Colombia and Peru is available in Weidner and Revord, "Colombian Shrimp Culture," *op. cit.* and Revord and Weidner, "Peruvian Shrimp Culture, *op. cit.*

134. Rivera, *op. cit.*, p. 38.

135. Maugle, personal communications, *op. cit.*, July 23, 1991 and Reese, personal communications, August 2, 1991

136. Panamanian fishmeal companies have not yet begun to produce the high quality fishmeal produced in Chile and that Peruvian companies are beginning to produce.

137. Paz, *op. cit.*

138. Tuñón, "Situacion Actual," *op. cit.*, p.22.

139. See for example, D. Hernandez de Santamaria, "El efecto de dietas experimentales en el crecimiento y sobreviencia de *Penaeus vannamei* cultivado en estanques," Licenciatura thesis, in preparation, 1990, University of Panama.

140. Rouse, "Identification," *op. cit.*, p. 5.

SECTION X. (Companies)

141. Rosenberry, *op. cit.*

142. One observer reports that in 1990, 12 farms were in serious trouble. Sjef van Eys, INFOPESCA, item 15.5.27, *World Shrimp Farming*, May 1990, p. 21.

143. DIGEREMA, "La Pesca en Panama," 1989, p.3.

144. Pang, *op. cit.*

145. Van Eys, *op. cit.*, May 17, 1990 and Nishio, *op. cit.*, November 5, 1991.

146. More, *op. cit.*, January 7, 1992 and Hamed L. Tuñón, Director Encargado, Dirección Nacional de Acuicultura, personal communications, January 19, 1992.

147. Van Eys, *op. cit.*, May 9, 1991 and January 10, 1992.

148. Agromarina, for example, has offered pl for as little as $4.00 per 1,000 to nearby farms. The growers, however, refuse to buy at these prices and in some cases wait months until wild pl becomes available for $1.00-$1.25 per 1,000. During this period their ponds either lay unused or are stocked at exceedingly low densities. Eric Gonzalez, Agromarina, personal communications, January 15, 1992.

149. Gonzalez, *op. cit.*, August 8, 1991.

150. Rivera, *op. cit., p. 38.*

151. Pang, personal communications, *op. cit.*

152. Van eys, *op. cit.*, May 9, 1991 and Nishio, *op. cit.*, November 5, 1991.

153. For an early assessment of the Agromarina facility, see Cornelius Mock, "Report on *Penaeid* Shrimp Culture Consultation and Visit, Guayaquil, Ecuador, South America, and Panama, Central America, August 12 to September 20, 1981," unpublished report.

154. Tuñón, "Situacion Actual," *op. cit.*, p. 17.

155. William More, Granada, cited in "Problems for Panama Shrimp Farmers," *op. cit.*

156. Appendices H1-2 provide sharply different data. Appendix H2 probably refers to the old ponds (120 ha) and appendix H1 appears to include recently constructed ponds (180 ha).

157. For details on the Ralston Purina experience see William R. More, "Operating an Integrated Shrimp Farm in Latin America: The Panama Experience," *Proceedings of the 34th Gulf and Caribbean Fisheries Institute*, (November 1981) August 1982.

158. For details see Joseph Massey and Bill More, Granada Corporation, "Granada Corporation," item 12.2.2, *Aquaculture Digest*, February 1987, pp. 5-6 and "Granada Buys Ralston Purina Farm," *Coastal Aquaculture*, February 1986, p.2. Recent press reports suggest that Granada has significant financial problems. William P. Barrett, "The Incredible Shrinking Empire," *Forbes*, November 11, 1991, p.48.

159. William More, Agromarina, personal communications, April 10, 1991.

160. Another source estimates as much as 750 ha of ponds (appendix H2).

161. "Problems for Panama Shrimp Farmers," *op. cit.*

162. The authors have extrapolated Pang's crop data to produce the annual yield data. Jorge Pang, item 15.5.28, *World Shrimp Farming*, July 1990, pp. 20-21.

163. Gonzalez, *op. cit.* January 15, 1992.

164. Agromarina official Eric Gonzalez was kind enough to review the above section on Agromarina and correct several dated references. Gonzalez, *op. cit.*, August 8, 1991.

165. Another source suggests only 250 ha (appendix H1), but a recent visitor to Panama confirmed a pond area of about 700 hectares.

166. Rolando Nix, General Manager, Aquachame, personal communication, January 8, 1992.

167. "Camaroneros herreranos piden mayor apoyo econ6mico del MIDA," *La Prensa*, April 1, 1984.

168. Franco (last name indistinct), Director, Sociedad Camaronera "Boca de Parita," personal communications, January 9, 1992.

169. An early review of the facilities is available in Cornelius Mock, "Penaeid Shrimp Culture Consultation and Visit. Ecuador, South America and Panama Central America, December 2-15, 1985," unpublished report.

170. Roberto Chamorro, Agromarina de Panama, item 12.10.16, *Aquaculture Digest*, October 1987, p. 13.

171. Van Eys, *op. cit.*, May 17, 1990.

172. Morales, "Situacion Actual," *op. cit*

173. Gonzalez, *op. cit.*, August 8, 1991.

174. Villageliu, *op. cit.*

175. Cornelio Lara, Gerente, Finca Marina Limocillo, personal communication, December 31, 1991. Mr. Lara plans to work as a consultant in Honduras. Additional information obtained from Leopoldo Arbale, Finca Marina Limocillo, personal communication, January 9, 1992.

176. Roberto Ramos, Owner, La Gallinaza, personal communications, January 9, 1992.

177. Van Eys, *op. cit.*, August 6, 1991. The authors have noted various spellings for this farm (las Huabas and las Guabas).

178. Morales, "Situacion Actual," *op. cit.*

179. Estimates on pond area vary from 75 ha (appendix H1) to 250 ha (appendix H2).

180. "Palangosta: Vision Futurista," *Matutino*, June 30, 1980.

181. Victor Ruben España, Fundador, Panlangosta, personal communications, January 21, 1992.

182. Tuñón, "Situacion Actual," *op. cit.*, p. 14.

183. España, *op. cit.*

184. Tuñón, "Situacion Actual," *op. cit.*, p.6.

185. The current President is Jorge Matsufuji.

SECTION XI. (Harvests)

186. Government officials were projecting a 1990 harvest of at least 4,600 tons. U.S. Embassy, Panama City, May 29, 1984.

187. "Gran interés por la cría de camarones," *Estrella*, April 15, 1980.

188. Sjef Van Eys, INFOPESCA, personal communications, May 16, 1990.

189. Rivera, *op. cit.* p. 37 and Van Eyes, *op. cit.*, May 16, 1990.

190. Maugle, "Present Status," *op. cit.*, pp. 2-3.

191. Rouse, "Identification", *op. cit.*, p.1.

192. The Panamanian fisheries agency (DIGEREMA) has published data showing that growers harvested about 800 t in 1982 and 1983. Harvests increased to 1,500 t in 1984, but declined in 1985 and 1986 and ranged from about 1,500-1,900 t annually between 1984-87 (appendix D1). These statistics are believed to significantly under estimate actual results. Industry sources contend that the amount of cultured shrimp is substantially higher than the Government figures. They claim that Government statistics for cultured harvests are low because smaller shrimp growers contract with processing plants in the port of Vacamonte where their shrimp is mixed in with--and becomes statistically part of--the trawler catch. U.S. Embassy, Panama, October 3, 1990.

193. Reinaldo Morales R., Jefe del Departamento de Investigaciones Acuícolas, Dirección de Acuicultura de Ministerio de Desarrollo Agropecuario, personal communications, September 27, 1991. Sjef Van Eys, Director of the INFOPESCA project in Panama indicates that a knowledgeable industry source also reports a 3,100 t 1990 harvest. Van Eys, *op. cit.*, January 9, 1992.

194. The reference in couched ambiguously, but suggests a 4,000 t harvest in 1990. "Problems for Panama Shrimp Farmers," *op. cit.*

195. Van Eys indicates that "... about a dozen outfits have run into trouble of one kind or another. This is not a good time for anyone." "Problems for Panama Shrimp Farmers," *op. cit.*

196. More reports that as few as 25 farms were actively raising shrimp in 1990. "Problems for Panama Shrimp Farmers," *op. cit.*

197. One report suggests that the farm with 1,000 ha of ponds was actually built during 1991. No further information, however, is available. INFOPESCA, "Panama: Bajo Produccion de Camaron de Cultivo," *Noticias Comerciales*, January 20, 1992.

198. See footnote 67. Some reports exceed 5,000 hectares. INFOPESCA, "Panama: Bajo Produccion," *op. cit.*

199. INFOPESCA, "Panama: Bajo Produccion," *op. cit.*

200. Morales, *op. cit.*

201. The U.S. Embassy in Panama City, which has also attempted to obtain data on cultured harvests, reports that obtaining accurate statistics was "virtually impossible." U.S. Embassy, Panama City, October 26, 1991.

202. Hamed L. Tuñón, Sub Director, Dirección Nacional de Acuicultura, personal communications, January 14, 1992.

203. Bob Rosenberry, "Panama," *World Shrimp Farming, 1991*, p. 7.

204. See, for example, More, *op. cit.*, January 7, 1992, Gonzalez, *op. cit.*, January 15, 1992, INFOPESCA, "Panama: Bajo Produccion," *op. cit.*. Some observers suggest even higher harvests. Gonzalez insists that most Panamanian farmers reported substantially reduced harvests in 1991.

205. Tuñón, *op. cit.*, January 10, 1992 and Gonzalez *op. cit.*, January 15, 1992.

206. Gonzalez, *op. cit.*, January 15, 1992.

207. Pang, personal communications, *op. cit.*, May 27, 1991.

208. Pang, personal communications, *op. cit.*, May 27, 1991.

209. Van Eys, *op. cit.*, January 10, 1992.

210. Tails per pound.

211. More, *op. cit.*

212. Gonzalez, *op. cit.*, August 8, 1991.

213. Rivera, *op. cit.*, p. 37.

214. Medium larges (36-40) represent only a small part of the harvest. Morales, "Situacion Actual," *op. cit.*

215. Some growers reportedly conduct double harvests, cropping the larger shrimp (about 10 gm) and then later harvesting the entire crop (6-14 gm shrimp). The harvest is conducted in less than the approximately 120-day cycle common in many other countries. Growers report the presence of stunted shrimp beyond this size and diminishing returns in continuing growout. Maugle, *op. cit.*, July 23, 1991. This system appears more of a strategy compensating for smaller shrimp than a cause.

216. Another observer also attributes small sized shrimp to inadequate domestic feeds. Gonzalez, *op. cit.*

217. Sjef van Eys, INFOPESCA, personal communications, May 9, 1991.

218. FAO, "Aquaculture Production, 1986-89," *FAO Fisheries Circular*, No. 815 Rev. 3, April 1991, p. 116.

219. Tuñón, "Situacion Actual," *op. cit., p.11.* Another Government official estimates 6.3 tons. Morales, *op. cit.*

SECTION XII. (Processing)

220. Rivera, *op. cit.*, p.37.

221. Rivera, *op. cit.*, p. 37 and Martínez Valdés, *op. cit.*

222. Rivera, *op. cit.*, p. 37.

223. Panama is one of the few countries shipping breaded shrimp to the United States. Panamanian breading operations are probably due to the long established trading patterns with U.S. importers and the extensive involvement of U.S. citizens in the industry. Paul Van Steenberg, United Seafood Importers, personal communications, August 7, 1991.

224. Data on production is not available, but U.S. import data is probably a good reflection of overall production levels. Breaded imports from Panama totaled 133 t in 1990, less than 3 percent of overall shrimp imports from Panama (appendix K5).

225. For details see DIGEREMA data in cuadro 9 of Tuñón, *op. cit.*

226. Panamanian and some other Central American shrimp appear to have a slightly more bluish cast than Ecuadorean shrimp. Van Steenberg, *op. cit.*

SECTION XIII. (Markets)

227. For details on the domestic market see Tuñón, "Situacion Actual," *op. cit.*, pp. 24-27.

228. Tuñón, "Situacion Actual," *op. cit., pp. 22-23.*

229. "Mercado de mariscos impulsará industria pesquera en Panamá," *La Prensa*, probably October 16, 1991 (source indistinct).

230. More, *op. cit.*, January 7, 1991.

231. Tuñón, "Situacion Actual," *op. cit., p. 23.*

232. The highs and lows are based on quantity, the value figures would have to be adjusted for inflation. The $46 million imported in 1980, for example, probably represents over $70 million in 1990 dollars.

233. The value of the 1990 shipments to the United States was only about half of the real value of 1980 shipments after adjustments for inflation.

234. For more details on the United States market, see Dennis Weidner, Tom Revord, and Randolf Wells, "Latin American Shrimp Culture, 1990-2000," *International Fishery Report,* in press and John Von Druska, "Shrimp Situation and Outlook-1990," NMFS Southeast Regional Office, 1991.

235. An excellent review of the European shrimp market is available in Helga Josupeit, "The European Shrimp Market: Coldwater Versus Warmwater," *GLOBEFISH Research Programme*, Volume 3, (FAO/GLOBEFISH: Rome, November 1989), 48 pp.

236. See Weidner, Revord, and Wells, "Latin American Shrimp Culture," *op. cit.*

237. Generally only small, more costly containers, are readily available for European shipments. Larger containers have to be contracted weeks in advance and schedule changes can prove costly.
Van Eys, *op. cit.*, January 10, 1992.

238. Weidner, Revord, and Wells, "Latin American Shrimp Culture," *op. cit.*

239. One observer stresses the impact of currency fluctuations and the economic advantages of heads-on sales in directing Ecuadorean product to Europe. Henry Branstetter, "Counter-Purchasing or Joint Ventures: Creative Way to Secure Shrimp Supplies," *Quick Frozen Foods International*, July 1991, pp. 96-98. Ecuador's European sales are becoming a very important part of its export markets. Revord and Weidner, "Ecuadorean Shrimp Culture," *op. cit.*

240. Few details are available on the shipments to Spain. One observer reports that some exporters dye (red dye #2) the shrimp before shipment. Maugle, personal communications, *op. cit.*, July 23, 1991. For details on the overall Spanish market see Dr. J. Varona, CONPESCO, "The Spanish Catering Market for Fishery Products: An Appraisal for Latin American Exporters," *GLOBEFISH Research Programme*, Vol. 9, (FAO: Rome, October 1990).

241. For details on the Japanese shrimp market see Weidner, Revord, and Wells, "Latin American Shrimp Culture," *op. cit.* and William D. Chauvin, "Change in the Japanese Shrimp Market," *Seafood Leader*, November/December 1991, pp. 109-116.

242. Neighboring Colombia has had some success in exporting trawler-caught pink shrimp to Japan where it has proved popular in sushi bars. Colombian growers, however, had no success in penetrating the Japanese market with their white shrimp. Tom Asakawa, Fisheries Trade Specialist, U.S. Embassy, Tokyo, personal communications, July 30, 1991.

243. For details on the Chinese shrimp culture industry, see Mark Wildman and Paul Niemeier, "Chinese Shrimp Culture," *International Fishery Reports* (IFR-91/43), June 14, 1991 and Tomohiro Asakawa, Fisheries Trade Specialist, U.S. Embassy, Tokyo, personal communications, July 30, 1991.

244. Weidner, Revord and Wells, "Latin American Shrimp Culture," *op. cit.*

SECTION XIV. (Postlarvae Supplies)

245. It is not known why the Panamanian growers are reluctant to purchase seedstock even when it is available at relatively low cost. One observer speculates that it might reflect low profit margins. Rouse, "Identification," *op. cit.*, p.3. This may well be the case as many of the small, extensive farms appear to be marginal operations.

246. Rivera, *op. cit.*, p. 37 and Rousch, personal communications, *op. cit.*, July 25, 1991.

247. Yosuke Hirono, Sensini, personal communications, July 18, 1991. Some observers report that the performance between wild pl and hatchery pl in Ecuador is narrowing. Revord and Weidner, "Ecuadorean Shrimp Culture," *op. cit.*

248. Small-scale growers obtain almost all of their postlarval seedstock from collectors at extremely low prices, often $1.00-1.25 per 1,000 postlarvae. Most simply refuse to pay higher prices for hatchery pl even if it means leaving their ponds unstocked for extended periods. Agromarina has attempted to sell pl locally, lowering prices to $4.00 per 1,000 pl, but report that few growers have purchased pl even at that price. Gonzalez, *op. cit.*, January 15, 1992.

249. One observer reports that Panamanian growers, unlike most other Latin American growers, generally prefer hatchery postlarvae. Tuñón says that hatchery pl are more "efficient." Tuñón, "Situacion Actual," *op. cit.*, p. 19.

250. The 1991 estimate of 0.5 billion is only a rough estimate. The authors would be interested in any actual data which may be available to readers.

251. Several sources suggest that much of the hatchery pl used domestically is used to stock growout ponds associated with the hatcheries. Several observers report considerable resistance on the part of independent growers, especially small operators, to purchasing hatchery pl because of its higher price. Gonzalez, *op. cit.*, January 15, 1992.

252. Such a quantity would be needed to stock 9,000 ha of ponds at 15 pl/m^2 and assuming 2 harvests per year and mortality rates of 30 percent (appendix J3). Another observer roughly confirms that projection, estimating a pl demand of 3.0 billion for 9,000 ha of ponds. Consejo Nacional de Inversiones, *op. cit.*

253. Gonzalez, *op. cit.*, August 8, 1991.

254. Agromarina and other large farms with hatcheries use hatchery pl almost exclusively. This means that most independent farms without associated hatcheries rely primarily on wild collected postlarvae.

255. Hughes, "Marine," *op. cit.*, p. 171.

256. Maugle, personal communications, *op. cit.*, July 23, 1991.

257. Paul Maugle, "Post Larvae Shrimp Mortality Reduction Study," *Artemia Newsletter*," May 1988, p. 11.

258. Hughes, "Marine," *op. cit.*, p. 171.

259. Rouse, "Identification," *op. cit.*, p. 2.

260. R.E. Turner, "Factors Affecting the Relative Abundance of Shrimp in Ecuador," 1986. See also Weidner, Revord, and Wells, "Latin American Shrimp Culture," *op. cit.*

261. Vielka Morales de Ruiz, Jefa de la Estación de Maricultura del Pacífico, "Situacion Actual," unpublished report, 1990.

262. Van Eys, *op. cit.*, January 10, 1992.

263. Maugle, *op. cit.*, p. 11.

264. The impact of collection on wild stocks has not been adequately studied to justify any reliable conclusions. Maugle, "Present Status," *op. cit.*, p.3.

265. Consejo Nacional de Inversiones, *op. cit.*

266. Wild pl in Ecuador sold for about $8 per 1,000 pl in early 1990. *Fish Farming International*, May-June, 1990. Prices have varied from a high of $25 per 1,000 during the 1985 pl crisis to $3-4 during the peak of the 1987 El Niño event. Solórzano, Carolina and Iván Saballos. *La Industria del Camarón en Ecuador: En Busca de una Nueva Estrategia*, prepared for the Instituto Centroamericano de Administración de Empresas (INCAE), August 1990 and Dennis Weidner, "Latin American Shrimp Culture, 1986-90" *International Fisheries Reports* (IFR-88/40), May 13, 1988. Ecuadorean observers have reported lower wild pl prices in 1991 as a result of unusual abundance. One observer in mid-1991 reported prices ranging from $5.30-5.75 per 1,000 postlarvae. Revord and Weidner, "Ecuadorean Shrimp Culture," *op. cit.*

267. Tuñón, "Situacion Actual," *op. cit.*, p.20 and Vielka Morales de Ruíz, Jefa de la Estación de Maricultura del Pacífico, personal communications, July 12, 1990. A more dated report suggests that wild pl in 1989 were selling for $0.25-1.00 per 1,000 postlarvae. Rivera, *op. cit.*, p. 38. Rosenberry also reports wild pl prices for $1.00 per 1,000, when available. Rosenberry, "Western Hemisphere," *op. cit.* Pl prices in Ecuador are calculated on the basis of numbers of the desired species (usually *P. vannamei*) in a particular shipment. Presumably prices in Panama are calculated in a similar fashion.

268. Hughes, "Aquaculture," *op. cit.*, p. 166 and David Hughes, Auburn University, item 10.5.39, *Aquaculture Digest*, May 1985, p. 22.

269. Massive pl collections could theoretically affect wild stocks. It is not proven, however, that the quantities of pl currently being collected in Panama are affecting catches. Climatic factors may cause much more serious fluctuations in pl supply than collectors. Female shrimp produce such large numbers of eggs that huge quantities of pl are naturally present in the ecosystem. Climatic variables have a major impact on pl survival. Mortalities due to predation and other natural causes cause much larger losses than current collection efforts. Thus collectors could theoretically remove substantial quantities of pl and have only a minimal impact on stocks. Of more immediate concern to the fishermen may be the impact of developing existing nursery habitat for ponds and other economic activities. U.S. Embassy, Panama City, August 6, 1985.

270. Tuñón, "Situacion Actual," *op. cit., p.34.*

271. Rivera, *op. cit.*, p. 38.

272. "Ministro Melo: Responden a inequitudes de la industria pesquera," *Estrella*, December 3, 1980.

273. U.S. Embassy, Panama City, July 30, 1984 and August 6, 1985.

274. Decree dated December 20, 1988.

275. For details see Dennis Weidner, "Ecuadorean Shrimp Hatcheries," *International Fishery Report*" (IFR-85/3B), January 30, 1985 and Revord and Weidner, "Ecuadorean Shrimp Culture," *op. cit.*

276. It is not just Panamanian hatcheries that are encountering difficulties. Hatcheries in other Latin American countries are reporting similar difficulties. The largest Latin American hatchery industry is located in Ecuador. About 30 Ecuadorean hatcheries currently have maturation facilities, but none have reported success at closed-cycle operations, producing seedstock from successive generations of the same broodstock. Roy Buddle, Regional Manager, SANOFI Aquaculture, personal communications, August 12, 1991.

277. Gary Parker, PACPL, personal communication, January 22, 1992.

278. Gonzalez, *op. cit.*, August 8, 1991.

279. Maugle, personal communications, *op. cit.*, July 23, 1991.

280. Even some of the leading producers have little or no hatchery production. Honduras has no hatcheries, but a Honduran company operates one in the United States. Dennis Weidner, "Honduran Shrimp Culture," *International Fishery Reports* (IFR-91/21), March 29, 1991. Mexico, which is rapidly expanding pond area, has initiated a major hatchery program. Even so, only three or four functioning hatcheries were reported in 1991. Wells and Weidner, "Mexican Shrimp Culture," *op. cit.* Some smaller but rapidly growing Latin American shrimp culture industries, such as the one in Guatemala, have no hatcheries at all. Dennis Weidner and Tom Revord, "Guatemalan Shrimp Culture," *International Fishery Reports*, (IFR-91/92), December 20, 1991.

281. Until 1991, the Ecuadorean Government prohibited pl exports and currently restricts such exports only to maturation-produced postlarvae. Revord and Weidner, "Ecuadorean Shrimp Culture," *op. cit.*

282. Rosenberry refers to the hatcheries as "world class." Bob Rosenberry, "Central America," *World Shrimp Farming*, 1990," p.23.

283. Morales, "Situacion Actual," *op. cit.*

284. Tuñón, *op. cit.*, p.20.

285. Such claims cannot be confirmed by the authors and almost certainly would be disputed by industry spokesmen in Ecuador.

286. Tuñón, "Situacion actual," *op. cit.,* p. 20. Another observer reports substantially different prices. More says pl sell in Panama for $5.50-6.50 per 1,000 and $8.00-9.00 when exported. More, item 15.5.28, *op. cit.* Another observer estimated that in 1990 hatchery pl were selling for $6.50-9.50 per 1,000, depending on the season and quantity ordered. Morales, *op. cit.* A more dated 1989 estimate suggested production costs of from $0.50 (1,000 nauplii) to $3.50-4.50 (1,000 postlarvae). Sales prices range from $5.00-6.50 (domestic sales) to $7.00-11.00 (export sales). Rivera, *op. cit.*, p.38.

287. Rosenberry, "Western Hemisphere," *op. cit.*

288. Jorge Pang, Agromarina, personal communication, May 20, 1991, as cited in item 16.9.25 *World Shrimp Farming*, September 1991, p. 21.

289. The one exception appears to be Agromar.

290. Ecuadorean hatcheries as of mid-1989 were selling pl at about $7.50 per 1,000 and had declined slightly to $7.00 by mid-1990. As a result of increasing abundance of wild pl, however, Ecuadorean pl prices dropped sharply in 1991. One observer reports that hatchery prices in mid-1991 had fallen to only $3.10-3.70 per 1,000 postlarvae. Revord and Weidner, "Ecuadorean Shrimp Culture," *op. cit.*

291. One exception appears to be Guatemala where abundant pl also appears to be keeping seedstock prices relatively low. Weidner and Revord, "Guatemalan Shrimp Culture," *op. cit.*

292. Tuñón, "Situacion Actual," *op. cit.,* p. 20.

293. Van Eys, *op. cit.*, May 17, 1990.

294. INFOPESCA, *Noticias Comerciales*, January 20, 1991.

295. There may be as many as 230 hatcheries in Ecuador. The large hatcheries, part of vertically operated integrated companies, may continue to operate as a result of the sizeable investments which the owners have made and the costs associated with closing such operations. Many small independent operations, however, would probably close. This would mean anywhere from 115-170 hatcheries could close in Ecuador if the current El Niño results in massive quantities of wild postlarvae. Buddle, *op. cit.* Other sources question the existence of such a large number of hatcheries. Robert Rosenberry, personal communications, January 24, 1992. Actual hatchery estimates by local observers vary widely. The wide range of available estimates on the number of Ecuadorean hatcheries may be due to the large number of extremely primitive operations which may only operate for short periods.

296. Gonzalez, *op. cit.*, January 15, 1992.

297. Ecuadorean officials have impeded pl exports in the past and newly issued regulations are somewhat ambiguous on hatchery exports. For details on the Ecuadorean hatchery situation, see Revord and Weidner, "Ecuadorean Shrimp Culture," *op. cit.*

298. One source reports that the hatchery operated at 80 percent of capacity during 1991 and was able to compete with the Ecuadorean hatcheries in the important Colombian market.

299. See Weidner and Revord, "Colombian Shrimp Culture," *op. cit.*

300. Long-established hatcheries in Ecuador and Panama continue reporting difficulties with closed-cycle maturation. Their difficulties relate to problems that are not easily resolved. It is unlikely that newly established Colombian hatcheries will resolve these problems during their start up-phase.

301. Gonzalez, *op. cit.*

302. The collection trawlers fish on grounds which generally produce high concentrations of *P. vannamei*. The masters have reported increasing success in finding areas with adult shrimp, which differs somewhat from the areas producing larger catches that are targeted by the commercial fleet. The Agromarina collection trawlers have specially designed gear and the masters limit tow times to ensure the shrimp can be brought onboard alive. Each trawler also has aquaria facilities for maintaining the individuals. Gonzalez, *op. cit.*

303. Agromarina has begun to import broodstock from El Salvador. The company wants to establish alternative sources in case domestic broodstock becomes scarce again. Gonzalez, *op. cit.*

304. Jorge Pang, Agromarina, item 15.7.33, *World Shrimp Farming*, July, 1990, pp. 20-21 and Gozalez *op. cit.* A detailed review of Agromarina's pl/nauplii production since 1987 is available in Jorge Pang, "La Calidad y Rendimientos en la Produccion de Camaron *Penaeus vannamei (Boone)* Provenientes de Nauplios de

Maduracion: El Caso de Agromarina de Panama, S.A.," unpublished report, 1990.

305. Gonzalez, *op. cit.*, August 8, 1991.

306. Pang, personal communications, *op. cit.*

307. William R. More, Granada Mariculture Technologies, item 15.5.28, *World Shrimp Farming*, May 1990, p.21.

308. More, item 15.5.28, *op. cit.*

309. Current Mexican regulations make pl/nauplii imports virtually impossible. One U.S. company reports successfully shipping pl to Mexico, but only after going through an elaborate process to prove that the pl were specific pathogen free (SPF). Despite a major hatchery program, the developing shrimp culture industry in Mexico is reporting increasing pl shortages and growers are increasingly asking for permission to import. For details see Randolf Wells and Dennis Weidner, "Mexican Shrimp Culture," *International Fishery Report*," in press.

310. Jorge Pang, Agromarina Technology and Sales Manager, item 16.1.29, *World Shrimp Farming*, January 1991, p. 20. Agromarina official Eric Gonzalez was kind enough to review the above section and to correct some of the data from dated references. Eric Gonzalez, personal communications, August 8, 1991.

311. The Ecuadorean Government has eased export restrictions and many Ecuadorean hatcheries reported excellent 1991 production runs. Revord and Weidner, "Ecuadorean Shrimp Culture," *op. cit.*

312. Gonzalez, *op. cit.*, January 15, 1992.

313. Nix, *op. cit.*

314. Gustavo Justines, Deputy Director, DIGEREMA, personal communications, January 23, 1991.

315. Villageliu, *op. cit.*

316. One observer reports a higher capacity. Justines, *op. cit.* Another observer reports that the capacity is only about 7 million pl per month. Morales, "Situacion Actual," *op. cit.*

317. "Proyectan producir 200 millones de camarones," *La Estrella de Panama*, July 21, 1984.

318. Ron Stanha, President, Pacific Larvae Center (PLC), personal communicaitons, May 29, 1992.

319. Robin Baily, PLC, personal communications, July 22, 1991.

320. Robin Baily, PLC, item 16.3.26, *World Shrimp Farming*, March 1991, p.21.; Robin Baily, PLC, personal communications, July 22, 1991; and Marc M. Harris, Director, PLC, personal communications, August 18, 1991.

321. Company officials claim survival rates of over 55 percent, compared to much of the Ecuadorean hatchery pl with survival rates of 35-40 percent. Such claims, however, cannot be confirmed by the authors.

322. Stanha, *op. cit.*

323. Justines reports a capacity of 20 million pl per month. Justines, *op. cit.*

324. España, *op. cit.*

325. Tuñón, "Situacion Actual," *op. cit.*, p. 7.

SECTION XV. (Government Policy)

326. Convenio de Préstamo BID-BNP-MIDA 98-ICIPN and Hughes, *op. cit.*, p. 166 and "Panama," *Aquaculture Digest*, June 1984, pp.4-5.

327. Tuñón, "Situacion Actual," *op. cit.,* pp. 14-15.

328. The Panamanian Government wanted this limitation because they determined smaller farms would not be economical and larger farms could obtain commercial credits. The farms eventually built under the program averaged less than 40 ha per farm. Some observers believe that farms of this size are not viable economic units.

329. Francis Peacock, IDB, personal communications, July 22, 1991.

330. Rene Costales, IDB Country Officer, personal communications, July 24, 1991.

331. Ing. Hugo Perez Athanasiades, Director de Acuicultura, Dirección Nacional de Acuicultura, MIDA, personal communications, June 20, 1991.

332. Hughes, "Aquaculture," *op. cit.*, p. 166.

333. Rivera, *op. cit.*, p.37.

334. Costales, personal communications, *op. cit.*, July 24, 1991 and March 27, 1992.

335. Van Eys, personal communications, *op. cit.*

336. Tuñón, *op. cit.*, January 14, 1992.

337. Decreto Numero 1 as reported in "Incentivos a industria de los camarones," *Estrella*, September 1, 1989.

338. Perez, *op. cit.*, June 20, 1991.

339. Gonzalez, *op. cit.*

340. Rivera, *op. cit.*, p. 38 and DIGEREMA, "La Pesca en Panama," 1989, p. 3.

341. Tuñón, "Situacion Actual," *op. cit.*, p.12.

342. Van Eys, personal communications, *op. cit.*

343. Not only would hatchery operators and farm managers benefit from duty-free imports, but feed producers would be able to reduce prices and improve quality if they were allowed duty-free privileges for imports of premixes and other dietary supplements. Tuñón, *op. cit., p. 30.* The Endara Administration is in the process of reducing import duties on a large number of products. U.S. Embassy, *op. cit.*, March 28, 1991. It is not yet known how many of the products desired by growers and hatchery managers are affected.

344. Tuñón, "Situacion Actual," *op. cit.*, pp. 35-36.

345. Tuñón, *op. cit.*, January 14, 1992.

SECTION XVI. (Legal Framework)

346. The employee tax credit partially offsets the land use charge for growers, especially for growers like Agromarina with their own processing plants. (Processing requires many more workers than growout

operations.) The Government's decision to charge growers only for land that they have or plan to develop, rather than the total area of concession they applied for, has sharply reduced the tax bills for many growers. Gonzalez, *op. cit.*

347. Tuñón, "Situacion actual," *op. cit.*, p. 31.

348. Anne R. Houtte, Nicola Bonucci, and William R. Edeson, "A Preliminary Review of Selected Legislation Governing Aquaculture," *Aquaculture Development and Coordination Programme*, ADCP/REP/89/42, FAO: Rome, 1989.

349. Reportedly growers applied under the names of relatives to create larger farm units. Maugle, personal communications, *op. cit.*, July 23, 1991.

350. Armando Martinez, Executive Assistant, OLDEPESCA, personal communications, April 25, 1991.

351. Perez, *op. cit.* June 20, 1991.

352. Decreto Ejecutivo No. 124, November 8, 1990.

353. One 1985 press reported estimated losses of $100,000. Cristobal Martinez, "Saquean estanques de camarones," *Republica*, March 7, 1985. See also U.S. Embassy, Panama City, July 30, 1984 and August 6, 1985. More current loss estimates are not available, but the problem continues to be serious. U.S. Embassy, Panama City, October 3, 1990.

354. U.S. Embassy, Panama City, September 9, 1986 and October 26, 1991.

SECTION XVII. (Credit)

355. U.S. Embassy, op. cit., September 13, 1991.

356. Rivera, *op. cit.*, p.36.

357. Newspaper reports suggest that about $6.5 million was designated for aquaculture loans. Carlos J. Nuñez L., "El BANCONAL explica agresivo apoyo para la acuicultura," *Critica*, February 4, 1987. It is unknown, however, what sums were actually dispersed for shrimp culture projects.

358. U.S. Embassy, November 6, 1991.

359. Tuñón, "Situacion Actual," *op. cit.*, p. 30.

360. For details see U.S. Embassy, *op. cit.*, March 28, 1991.

361. U.S. Embassy, *op. cit.* March 28, 1991.

SECTION XVIII. (Technical Capability)

362. Lic. Hamed L. Tuñón, Director Encargado, Dirección Nacional de Acuicultura, personal communications, November 22, 1991.

363. Tuñón, "Situacion Actual," *op. cit.,* pp. 7-8.

364. Hughes, "Marine," *op. cit.*, pp. 168-169.

365. "Basically, we're trying to describe what's happening in that pond system in order to lay down some basic knowledge on what we can then apply the research for more specific problems that affect the industry. It seems that what we have done is jumped off into raising shrimp without knowing a lot of real inner goings on in a fish pond. So essentially we're trying to describe holistically what's happening and then relate it to productivity of the final animal, in this case being shrimp. At the same time, we like to apply this basic information as a control, then, for more practical experiments. So, while we are carrying this out at the research station in Panama, we then do a lot of other more practical type research, such as working with manures and inorganic fertilizers, different stocking rates, and so forth." Hughes, "Aquaculture," *op. cit.*, p. 166.

366. This facility was seriously damaged during December 1989 as a result of the fighting between Noriega partisans and U.S. forces. The Government is still rebuilding and restoring lost equipment. U.S. Embassy, Panama, October 3, 1990. Local observers report that the looting which ensued during the absence of law enforcement caused much of the damage. Van Eys, *op. cit.*, September 3, 1990.

367. The authors have been able to obtain no information on University of Panama shrimp culture activities or aquaculture in general. While the authors have not been able to identify published studies, there does appear to be some activity in progress. Some graduate students, for example, have prepared papers on shrimp culture. See: "Sources" (Hernandez, Quesada, and Quiroz). Additional papers were prepared, but have not been cited in this report. In addition, Panamanian researchers have delivered papers on shrimp culture at the National Science Conference held at the University. See: "Sources" (de Leon, Lasso de la Vega, Lore, and Torres).

368. Tuñón, "Situacion Actual," *op. cit.*, p.32 and Tuñón, *op. cit.*, January 14, 1992.

369. Biol. Lorenza Bustamente de Contreras, "Camarones: Algunos virus pueden enfermar a estas deliciosas criaturas causando serios daños," *Nuestro Camaron*, March 7, 1987, p.12.

370. Tuñón, "Situacion Actual," *op. cit.*, p. 17. Tuñón reported 29 farms in a more recent communication. Tuñón, *op. cit.*, January 14, 1992.

371. The training program extends over a 6-month harvest cycle, beginning with pl production through the growout phase. Tuñón, *op. cit.*, pp. 10-11 and 17.

372. Tuñón, "Situacion Actual," *op. cit., p. 32.*

373. Rouse, "Identification," *op. cit.*, p. 9.

374. U.S. Embassy, Panama City, May 29, 1984.

375. Tuñón, "Situacion Actual," *op. cit.*, pp. 8 and 17.

376. Company advertising flyer, item 12.4.20, *Aquaculture Digest*, April 1987.

377. Lic. Tuñón has informed the authors that he does have such information. Tuñón, *op. cit.*, November 22, 1991.

SECTION XIX. (Foreign Assistance)

378. Hughes, "Marine," *op. cit.*, p.170.

379. "Operational Summary," *The Courier*, no. 128, July-August 1991, xiii.

380. Julio César Aizprúa, "Países centroamericanos valorizan sector pesquero," *La Prensa*, September 12, 1991; OLDEPESCA, "Programa Regional de Apoyo al Desarrollo de la Pesca en el Istmo Centroamericano: Plan de Trabajo, Primer Año de Operaciones," July 9, 1991, pp. 40-52, and Armando Martínez Valdés, Asistente Ejecuativo, OLDEPESCA, personal communications, August 27, 1991.

381. "Panama," *The Caribbean Aquaculturist,"* December 1988, p. 17.

382. Jacques Perrot, France Aquaculture, item 10.2.8, Aquaculture Digest, February 1985 and U.S. Embassy, Panama City, August 6, 1985.

383. Hughes, "Marine," *op. cit.*, p.170. Little information is available on Swedish activities. One recent report indicated that the Swedish Center for Coastal Development and Management of Aquatic Resources (SWEDMAR) with Swedish International Development Authority (SIDA) funds are assessing the impact of Colombian shrimp farms on mangroves. SWEDMAR, "Minor Field Study on the Impacts of Shrimp Farming on Mangroves," *IOCARIBE News*, October 1991, p.2. The study will be of interest to growers in Panama and many other Latin american countries.

384. Tuñón, "Situacion Actual," *op. cit.,* p. 6.

385. "Estación de camarones," *Análisis* July 1984, p. 49.

386. Cheng-Fei Huang, Fisheries Specialist, Economic Division, Coordinating Council for North American Affairs, personal communications, August 27, 1991.

387. Linos Cotsapas, item 12.9.13, *Aquaculture Digest*, September 1987 and item 11.8.4, August 1986.

APPENDICES

Appendix A.--Panamanian shrimp culture addresses.

Government Agencies

Aquaculture Program
Banco Nacional de Panama (BNP)
PO Box 5220
Panama 5, PANAMA
Telephone: (507) 64-6613

Dirección General de Recursos Marinos
(DIGEREMA)
Ministerio de Comercio e Industria
PO Box 3318
Panama 4, PANAMA
Telephone: (507) 27-4211, 27-4691, 27-3528
FAX: (507) 27-3104

Dirección Nacional de Acuicultura (DINAAC)
Ministerio de Desarrollo Agropecuario (MIDA)
Apartado 1260, Zona 1
Panama, PANAMA

Dirección Nacional de Acuicultura (DINAAC)
Ministerio de Desarrollo Agropecuario (MIDA)
Apt. Postal 5390
Santiago de Veraguas
Telephone: (507) 98-4388,4250,4257 ext. 185
FAX: (507) 98-3761

Promotion Groups

Asociación Panameña de Acuicultores (APAC)
PO Box 6-6631
El Dorado
Panama 6, PANAMA
Telephone: (507) 23-0697
FAX: (507) 23-0697

Centro de Documentacion e Informacion de
Acuicultura (CEDIA)
Address unavailable
PANAMA

Federación de Cooperativas Salinero de los Santos de Panama
Apt. Postal 320
Menagre, Los Santos
PANAMA
Telephone: (507) 96-0246; 96-9995

Farms

(Sociedad Industrias) Acuimar
Address unavailable
Parita, Herrera
PANAMA
Telephone: (507) 94-2054

AGRICOLA
PO Box 6-1693
El Dorado
Panama City
PANAMA

(Melanio) Aguilar
Address unavailable

(Corporacion) Agromar
Address unavailable
Bejuco, Panama
PANAMA
Telephone: (507) 23-0550

Agromarina de Panama
Apt. 6-4600
El Dorado, Panama City
PANAMA
Telephone: (507) 500-161
FAX: (507) 500-056

Agromarina de Panama
Caja Postal 50
Aguadulce, Coclé
PANAMA
Telephone: (507) 97-4414, 5082, 5118

AQUACHAME
Apt. 8475
Panama 7, PANAMA
Telephone: (507) 50-6166; 64-2537
Telex: 368699
FAX: (507) 50-6067; 63-8269

(Horacio) Arauz
Address unavailable
Aguadulce, Coclé
PANAMA
Telephone: (507) 97-4319
FAX: (507) 97-6418

Belisario Medina Tuñon
Address unavailable
Penonome, Coclé
PANAMA
Telephone: (507) 97-9714

Bravo Mar
Address unavailable

(Faustino) Cabadas
Los Guabinos
Address unavailable
Aguadulce, Coclé
PANAMA
Telephone: (507) 97-4420

Camaronera Boca de Parita
PO Box 6-1291 El Dorado
Boca de Parita, Herrera
PANAMA
Telephone: (507) 96-2566; 64-0909

Camaronera de Coclé (CAMACO) (new name for CANASA)
Aguadulce farm site:
    c/o Azucarera La Estrella
    Apt. 49
    Aguadulce, Cocle
    PANAMA
Panama City Office:
    Apt. 8404
    Panama 7
    PANAMA
    Telephone: (507) 36-1150, 36-1711
    FAX: (507) 36-1079

Camaronera de Nata (CANASA)
See Camaronera de Coclé

Camaronera El Nanzal
PO Box 6-4533
El Dorado
Panama City
PANAMA
Telephone: (507) 97-2245

Camaronera Libano, SA
PO Box 6-1291
El Dorado
Panama City
PANAMA
Telephone: (507) 60-8883, 8603, 8537, 8705; 64-9562, 9547

Finca Camaron, SA
Calle Oeste Boulevard
Casa No. 5319
Aguadulce, Coclé
PANAMA
Telephone: (507) 97-4924

Finca Marina Limocillo
148 Calle San Jose
Aguadulce, Coclé
PANAMA
Telephone: (507) 97-4483

Camaronera Trinidad
General Delivery
Aguadulce, Coclé
Telephone: (507) 97-4302

(Felipe Ramón) Cedeño
Address unavailable
Aguadulce, Coclé
PANAMA

(El) Chumical
Address unavailable
Aguadulce, Coclé
PANAMA

Cooperativa Che Paulim
Address unavailable
Santa Ana, Los Santos
PANAMA
Telephone: (507) 96-8283

Cooperativa Salineros de Servicios Multiples
Marin Campos RL
General Delivery
Aguadulce, Coclé
PANAMA
Telephone: (507) 97-4816

(Corporacion) del Camaron
Address unavailable
Libano, Panama
PANAMA
Telephone: (507) 50-6067, 6061

Desarrollo Camaronero del Pacifico (DECAPASA)
Address unavailable
Menagre, Los Santos
PANAMA
Telephone: (507) 96-4797; 64-1439; 61-8503

Empresa Produccion y Turismos, SA
Address unavailable
Aguadulce, Coclé
PANAMA
Telephone: (507) 97-4346

(Solo) Espipoza
Address unavailable
Felipillo, Panama
PANAMA

(La) Gallinaza
Address unavailable
Nata, Coclé
PANAMA
Telephone: (507) 97-5021

Granja Marina
Address unavailable
Penonome, Coclé
PANAMA
Telephone: (507) 97-9293

Granja Marinas Vargas
Address unavailable
Anton, Coclé
PANAMA

Granjas Marinas
Address unavailable
Bejuco, Panama
PANAMA
Telephone: (507) 50-6166

Grupo de Venezolanos
Address unavailable
Felipillo, Panama
PANAMA

(Horacio) Herrera
Address unavailable

Hacienda El Rosario
Address unavailable
Penonome, Coclé
PANAMA
Telephone: (507) 66-9107; 97-9836

(Las) Huabas
Address unavailable
Parita, Herrera
PANAMA
Telephone: (507) 96-5254
FAX: (507) 96-5245

(La) Hundita de Oro
Address unavailable
La Honda, Los Santos
PANAMA
Telephone: (507) 96-2362

Langostinos Rub-Car
Address unavailable
Aguadulce, Coclé
PANAMA
Telephone: (507) 97-4367, 4962

Palangosta
PO Box 006
Aguadulce, Prov. de Coclé
PANAMA
Telephone: (507) 97-4961
FAX: (507) 97-6410

Rachung
Address unavailable
Aguadulce, Coclé
PANAMA
Telephone: (507) 97-5166, 5021

Salinero de Guarare
Address unavailable
Guarare, Los Santos
PANAMA

(Humberto) Sánchez
Address unavailable

(Fernando) Vargas
Address unavailable
Telephone: (507) 97-4162

Salvador Zarzavilla
General Delivery
Guarare, Los Santos
PANAMA
Telephone: (507) 94-5485

Hatcheries

Agrolab
Via 120, Edif. 206
Apdo. 1668
Panama City, Zona D
PANAMA
Telephone: (507) 23-0550/0382
FAX: (507) 69-0944

AQUACHAME
(Hatchery located at Punta Chame)
Apt. 8475
Panama 7,
PANAMA
Telephone: (507) 50-6166; 64-2537
Telex: 368699
FAX: (507) 50-6067; 63-8269

Camaronera de Cocle
(See listing under "Farms")

Camaronera de Nata (CANASA)
Apt. 6-7359
El Dorado
Panama City
PANAMA
Telephone: (507) 63-9855, 63-9463, 63-9750, and 63-9646

Corporacion Agromar
Hatchery address unavailable
Punta Chame
PANAMA

Granjas Marinas
Hatchery address unavailable
Bejuco
PANAMA

Maricultura del Pacifico
Hatchery address unavailable
Vacamonte, PA
PANAMA

Palangosta
Hatchery address unavialable
Aguadulce
PANAMA

Pacific Larva Centre (PLC)
Apt. 6-922
Estafeta El Dorado
Panama City
PANAMA
Telephone: (507) 23-2980; 64-7198
FAX: (507) 69-2568; 64-7068

Pacific Postlarvae
Address unavailable

Consultants

Empresa Consultora y de Servicios de Acuicultura, SA
PO Box 25
Santiago, Veraguas
PANAMA
Telephone: (507) 97-5381; 98-4125, 4588, 4700

MARYTEC, S.A.
P.O. Box 6-6439
El Dorado, Panama 6A
PANAMA

Mariculture Management Services, Inc
Apartado 6-922
El Dorado, Panama City
PANAMA
Telephone: (507) 60-2847

Feed Companies

INASA
Address unavailable

Nutricion Animal, S.A. (NASA)
Apt. 1795
Panama 1
PANAMA
Telephone: (507) 500-056
FAX: (507) 270-487

Rivoflavia
Apt. 8475
Panama 7, PANAMA
Telephone: (507) 50-6067, 6161

Research Groups

Universidad de Panama
Departamento de Biologia Marina
Estafeta Universitaria
Panama City
PANAMA

Estacion Experimental de Aguas Estuarinas "Ing. Enrique Euseñat"
DINAAC/MIDA
Aguadulce, Coclé
PANAMA
Telephone: (507) 97-5381

Estacion de Maricultura del Pacifico
DINAAC/MIDA
Puerto de Vacamonte
PANAMA

Appendix B.--Panama. Shrimp species

Scientific	Species English*	Spanish*
Marine		
Caribbean		
Penaeus	Penaeids	Penidios
brasiliensis	Red/pink spotted	Rosado con manchas
notialis	Southern pink	Rosado sureño
schmitti	Southern white	Blanco sureño
subtilis**	Southern brown	Café sureño
Xiphopenaeus kroyeri	Atlantic seabob	Siete barbas
Pacific		
Heterocarpus vicarius	Northern nylon	Nailón norteño/camello, torobado
Penaeus	Penaeids	Penidios
brevirostris	Crystal/pink	Cristal/rojo o rosado
californiensis	Yellow leg/brown	Patiamarillo
occidentalis	Western white	Blanco del Pacifico/langostino blanco
stylirostris	Blue	Azul/camaron azul
vannamei	Whiteleg	Patiblanco/langostino blanco
Solenocera		
agassizi	Kolibri	Chupaflor/Fidel
florea	Flower	Picaflor/Fidel
Trachypenaeus		
byrdi	Carabali	Carabalí/tigre
faoe	Indio	Fijador indio/indio
pacificus	Zebra	Cebra
Xiphopenaeus riveti	Pacific seabob	Botalón/tití
Freshwater		
Macrobrachium	River prawn	Agua dulce
acanthurus	Cinnamon	Canela
americanum	Cauque	Cauque
carcinus	Painted	Pintado
olfersii	Buchura	Buchura

* FAO terms, commonly used Panamanian names after slash in Spanish column.
** Formerly considered to be a subspecies of P. aztecus. Previously this species was not distinguished

from P. brasiliensis.
Note: Unconfirmed reports suggest good 1991 catches of a deepwater species referred locally as "cabezon."
The authors are unsure of precisely to which species the fishermen are referring.
Source: FAO. "Shrimps and Prawns of the World" FAO Species Catalogue, Vol. I, Rome, 1980.

Appendix C.--Latin America. Sea surface temperatures, 1989-91

Year/ Month	Pacific				Atlantic		
	Northern Peru	Southern Ecuador	Colombia*	Panama	Panama	Colombia	Northeast Brazil
	Degrees Celcius						
1989							
January	21	23	26	**26-27**	**27**	27	27
February	23	24	24	**25-26**	**26-27**	26	27
March	23	25	26-28	**26**	**27**	27	26
April	23	25	27	**27-28**	**27-28**	27	26
May	19	21	26-27	**27-28**	**27-28**	28	27-28
June	20	24	26-27	**27-28**	**28**	27-28	27
July	20	22	26-27	**28**	**28**	28	27-28
August	19	23	26-28	**28**	**29**	29	26-27
September	18	22	26-28	**28-29**	**29**	29	27
October	19	23	26-28	**28**	**29**	29	27
November	19	22	26-27	**28**	**28**	28	27-28
December	21	25	26-27	**27**	**28**	28	27
1990							
January	22	25	26-27	**27**	**27**	27	27
February	22	25	26	**26-27**	**26-27**	26-27	27
March	23	26	27-29	**27-29**	**27**	26-27	27
April	21	24	26-27	**27-28**	**27**	26-27	27
May	22	25	27-28	**28**	**29**	28-29	28
June	21	24	27-28	**28**	**28**	28-29	27
July	20	24	26-28	**28**	**29**	28-29	27
August	20	25	25-28	**28**	**28**	28	25-27
September	21	25	25-28	**28-29**	**29**	29	25-27
October	19	22	25-27	**27**	**29**	28	26-27
November	20	22	25-28	**27-28**	**29**	28	26-27
December	21	22	26-27	**27**	**27**	27	27
1991							
January	23	24	26-27	**27-28**	**27-28**	27-28	27
February	25	26	26	**26-27**	**26-28**	26-27	27
March	24	25	27	**27-28**	**27-28**	27	27-28
April	23	24-25	27-28	**28-29**	**28-29**	27-28	28-29
May	22	24	27-28	**28**	**29**	27	28
June	21	25	27-28	**28**	**28**	27-29	27-28
July	20	24	27-28	**28**	**28**	27-28	26-27
August	20	24	27-28	**28**	**28**	27-28	26-27
September	19	23	26-27	**28**	**28**	28	25-26
October	20	25	26-28	**28-29**	**28**	28	26-27

Note: Temperatures are approximations based on visual estimates from map graphics.
NA - Not available
* The lower figure in the column is the temperature off southern Colombia, where all of the country's shrimp farms are currently clustered.
Source: Climate Analysis Center. National Weather Service. National Oceanic and Atmospheric Administration. TOGA Analysis.

Appendix D1. -- Panama. Total shrimp production, wild-caught and cultured, 1982-89.

Year	Production			Share Cultured
	Capture	Culture*	Total	
	1,000 Metric tons**			Percent
1982	10.9	0.8	11.8	7.0
1983	10.6	0.8	11.5	7.0
1984	8.9	1.5	10.4	14.0
1985	11.3	1.4	12.7	11.0
1986	9.5	1.2	10.7	11.0
1987	6.2	1.9#	8.2	23.0
1988	5.4	2.5	8.0	32.0
1989	8.6	2.3	10.9	21.0
1990	NA	2.2E	NA	NA

* Licda. Morales at the Estación de Maricultura del Pacífico provides lower estimates
** Liveweight
# Confirmed by Rivera, op. cit.
E - Estimate
NA - Not available
Note: Industry sources believe that these DIGERMA statistics substantially under estimate pond harvests. They are presented here as they are the official Panamanian statistics and researchers investigating Panamanian shrimp culture will see these used in various articles. The DIGEREMA statistics for cultured shrimp are reportedly low because smaller shrimp cultivators contract with processing plants in the port of Vacamonte where their shrimp is mixed in with--and becomes statistically part of -- the production of ocean-caught shrimp. Significant discrepancies exist between this data and other data available from Panama (appendix D2) and the data published by FAO (appendix D3).
Source: DIGEREMA, Ministerio de Comercio e Industrias (1982-88); William More, Agromarina de Panama, personal communications, April 10, 1991 (1989-90 data).

Appendix D2.--Panama. Total shrimp production, wild-caught and cultured, 1985-89.

Year	Production			Share Cultured
	Capture	Culture*	Total	
	1,000 Metric tons**			Percent
1985	10.1	2.6	12.6	21
1986	9.5	3.0	12.5	24
1987	7.5	2.8	10.4	27
1988	7.6	3.5	11.1	32
1989	9.8	3.5	13.3	26
1990	5.1E***	3.5E♦	8.6	41
1991	NA	2.7E♦♦	NA	NA

E - Estimate
* Licda. Morales at the Estación de Maricultura del Pacífico provides lower estimates
** Liveweight
*** Contraloría General as reported by Tuñón, op. cit., p.21. The Directorate of Marine Resources reports a wild catch of about 4,000 tons. U.S. Embassy, Panama City, October 26, 1991.
♦ Some observers suggest a lower harvest of only about 3,000 tons.
♦♦ NMFS has received estimates from Panamanian sources varying from 2,500-5,700 tons. Given the difficulties reported by several farms, the lower range of these estimates may prove to be the most accurate.
NA - Not available
Note: Significant discrepancies exist with appendix D1. The authors believe that this is the more accurate data set.
Source: Departamento de Evaluación Pesquera, DIGEREMA, MICI, Panamá, 1991 as cited by DINAAC (1985-89 data).
Various industry and Government sources (1990-91 data).

Appendix D3.--Panama. Marine shrimp catch and pond harvest, by species

Year	Penaeids			Small species*	Other**	Total
	Pink	Whites	Total			
			1,000 Metric tons#			
1980	3.4	3.5	7.0	2.9	0.6	10.5
1981	2.3	5.5	7.8	6.9	0.6	15.3
1982	2.2	4.2	6.4	6.5	1.8	14.7
1983	2.2	4.8	7.1	5.9	1.2	14.2
1984	2.8	3.4	6.2	3.7	0.4	10.3
1985	4.3	4.6	8.9	6.0	1.0	15.9
1986	3.9	3.5	7.5	2.7	2.9	13.1
1987	1.9	3.5	5.4	2.0	0.5	7.8
1988	1.3	2.7	3.9	2.0	0.1	6.0
1989	2.9	2.7	5.6	4.1	0.5	10.2

* Primarily Trachypenaeus byrdi and Xiphopenaeus riveti.
** Natatania
# Livewight
Note: FAO data is supplied by the Panamanian Government and supposedly includes both catches and pond harvests. The discrepancies with appendices D1, D2, and D4 are unexplained.
Source: FAO, Yearbook of Fishery Statistics, 1989.

Appendix D4.--Panama. Marine shrimp catch and pond harvest, by species

Year	Penaeids			Small species*	Other**	Total
	Pink	Whites	Total			
			1,000 Metric tons#			
1982	1.1	2.3	2.9	2.9	1.3	6.9
1983	0.8	2.4	3.2	3.4	0.9	7.4
1984	1.4	2.8	4.2	2.2	0.4	6.8
1985	1.8	2.8	4.6	3.0	0.7	8.3
1986	1.4	2.3	3.7	1.7	1.5	6.9
1987	0.8	2.9	3.6	1.2	0.5	5.3
1988	0.9	2.9	3.8	1.2	0.2	5.2
1989	1.5	2.6	4.1	2.1	1.0	7.1
1990	1.2	2.0##	3.2	1.1	0.6	4.9

* Primarily Trachypenaeus byrdi and Xiphopenaeus riveti.
** Carabali, Fidel, and Cabezón
# Liveweight
Includes an unrealistically low estimate (900 t) of pond harvests.
Note: Discrepancies with appendix D1-D3 are unexplained.
Source: DIGIREMA, unpublished statistics as cited in U.S. Embassy, Panama City, October 3, 1990 and October 26, 1991 (1983-90 data) and DIGEREMA as cited in INFOPESCA, Noticias Comerciales (1982 data).

Appendix D5.--Panama, shrimp catch, by fishery

Year	Fishery		Total
	Commercial	Artisanal	
	1,000 Metric Tons		
1986	6.1	0.1	6.2
1987	4.0	0.1	4.1
1988	3.3	0.2	3.5
1989	5.8	0.2	6.0
1990	3.9	0.1	4.0

Note: Discrepancies with other D series appendices are unexplained. The data is included in this report to provide one estimate of the relative importance of the commercial and artisanal fisheries. It is likely, however, that the official statistics understate the importance of the artisanal catch.
Source: DIGEREMA as cited by U.S. Embassy, Panama City, October 3, 1990 and October 26, 1991.

Appendix D6.--Panama. Total cultured shrimp production, freshwater and marine, by species, 1986-90.

Year	Freshwater	Marine: P. vannamei	Marine: P. stylirostris	Total Marine	Total All species
		Metric tons*			
1986	16	1,740	1,260	3,000	3,016
1987	7	1,676	1,164	2,840	2,847
1988	11	2,081F	1,446F	3,527F	3,538F
1989	5	2,062F	1,433F	3,495F	3,500F
1990	10	NA	NA	NA	NA

*liveweight
E - Estimate
F - FAO estimate
NA - not available
Note: Considerable discrepancies exist with the other D series data sets, except appendix D2. See note in appendix D1 for possible explanation.
Source: FAO, "Aquaculture Production, 1986-89," FAO Fisheries Circular, No. 815 Rev. 3, April 1991, p. 116 (1986-89 data).

Appendix D7.--Latin America. Cultured shrimp harvests, 1985-91

Country	1985	1986	1987	1988	1989	1990	1991
				1,000 Metric Tons			
Ecuador	30.2	43.6	69.2	70.1	64.2	70.0E	100.0P
Colombia	0.1	0.2	0.5	1.3	3.0	6.0	9.8P
Mexico	0.1	0.2	0.8	2.4	3.2E	5.4E	6.7P
Honduras	0.6	1.3	1.9	4.5	3.4	5.0E	6.8P
Peru	1.1	1.2	2.0	2.3	4.0	5.0E	5.5P
Panama	**2.6**	**3.0**	**2.8**	**3.5**	**3.5E**	**3.5E**	**2.7P**
Brazil*	0.8E	0.9E	1.0E	1.4E	2.0E	2.5E	2.5P
Guatemala	0.5	0.6	0.8	0.8	0.8	1.1	2.4P
Others	0.8	1.0	1.0	1.6	1.8E	2.5E	3.5P
Total	36.8	52.0	80.0	87.9	85.9	101.0	139.9P

E - Estimated
NA - Not available
P - Projected
* Includes substantial quantities of freshwater shrimp.
Source: Various country sources

Appendix D8.--Latin America. Ecuadorean share of regional cultured harvest

Year	Pond harvest: Ecuador	Pond harvest: Other	Total	Ecuadorean share
	1,000 Metric tons			Percent
1985	30.2	6.6	36.8	82
1986	43.6	8.4	52.0	84
1987	69.2	10.8	80.0	87
1988	70.1	17.7	87.9	80
1989	64.2	21.7	85.9	75
1990	70.0E	31.0E	101.0	69
1991	100.0P	39.9P	139.9P	71

Source: Various country sources

Appendix E1.--Panama. Basic marine shrimp culture data, 1985-91

Year	Pond area	Harvest	Exports	
			Actual	Liveweight*
	Hectares	Metric tons**		
1985	2,499	2,557	905	1,508
1986	3,013	3,000	753	1,255
1987	2,847	2,840	1,231	2,051
1988	3,531	3,527	1,634	2,738
1989	3,718	3,495	1,063	1,772
1990	3,800E	3,500E♦	NA	NA
1991	4,200E	2,700E♦	1,800E	3,000E

E - Estimate
* Harvest data is expressed in liveweight and exports in tail weight. Comparative liveweight equivalencies for the export tail weight is provided for comparative purposes.
** Approximate liveweight equivalencies.
♦ The authors have received widely differing reports on 1990 and 1991 harvests. Various observers estimate a somewhat lower harvest of only about 3,000 tons. Observers also provide widely varying 1991 harvest data ranging from 2,500-5,200 tons. The authors are unable at this time to authoritatively estimate actual harvests. The lower end of the range, however, may in fact be more accurate as several, but not all, local observers report that the harvest declined as a result of disease problems and an usually pronounced dry season.
Note: The authors do not understand the substantial difference between harvests and exports. Most reports suggest that almost all of the cultured shrimp harvest is exported.
Source: Departamento de Programación y Evaluación, DINAAC, MIDA, Panamá, 1991. As cited in DINAAC (1985-89 data); Rosenberry, World Shrimp Farming, 1991; More, Agromarina, personal communications, January 7, 1992; Gonzalez, personal communications, January 15, 1991; Tuñón, personal communications, January 14, 1992, and Van Eys, INFOPESCA, personal communications, January 9, 1992 (1990-91 data). The various sources (Gonzalez, More, Rosenberry, Tuñón, and Van Eys) differ sharply on 1991 results.

Appendix E2.--Panama. Aquaculture pond/water surface area, 1989

Type	Freshwater		Marine♦		Total	
	Ponds*	Area	Farms	Area	Farms	Area
	Number	Hectares	Number	Hectares	Number	Hectares
Ponds	1,631	96	38	3,718	1,719	3,827
Embalsas**	244	83,865	-	-	244	83,865
Concrete tanks***	68	Negl.	18	Negl.	86	Negl.

* The sources assumption for this table is that the small-scale individuals culturing freshwater fish and shrimp, largely on a subsistence basis, have only one pond on their farms.
** Embalsa means an area of water, usually freshwater. The authors are unclear as to its precise meaning in this data set but it includes lakes and the reservoirs behind hydroelectric and irrigation dams.
*** Government research operations.
♦ Almost entire shrimp farms.
Source: DINAAC, MIDA, as cited in Tuñon, "Situacion Actual," op. cit., pp. 1, 16.

Appendix F.--Panama. Shrimp culture yields, 1989

Group	Ponds	Crops	Yield	
			Crop	Year
	Hectares	Per year	Metric Tons*	
1	650	2.5	0.6	1.6
2	1,223	2.0	NA	NA
3**	961	1.5	0.3	0.5

* Liveweight
** mostly extensive farms
Source: Enid Raquel Rivera Quintero, Chief, Department of Marine Resources, Herrera Province, "Culture of Penaeus Shrimp in the Republic of Panama," INFOFISH International, 3/89, p. 37.

Appendix G1.--Latin America. Fishmeal prices, October-November 1991

Origin	Date	Protein content	Price	Conditions
		Percent	US $/MT	
Argentina	11/13/91	65	710*	C+F Taiwan PC
Chile	10/23/91	66♦	570♦♦	CIF, Ex-store UK
Chile	10-12/91	NA	425	CIF, Hamburg
Panama	**10/9/91**	**58-60**	**340-360**	**FOB Panama**
Peru	10/91	64	415-420	FAS Peru
Peru	10/91	65-66	430-440	FOB Peru
Peru	10/91	65-66	500-510	C+F Germany/Europe
Peru	10/9/91	64	495-500	C+F Asia
Peru	10/4/91	65**	510	C+F Hamburg

* Possible printing error
♦ Pellets
♦♦ £335
** In bulk
Source: INFOPESCA, Noticias Comerciales, No. 21/91, November 20, 1991.

Appendix G2.--Panama. Feed prices

Company	Location	Protein content 20	25	30	35	40
				US$		
INASA	Coclé	16.75	18.90	19.80	23.00	24.00
NASA*	Chiriquí	21.00	22.00	23.50	26.50	31.50
RIVOFLAVIA	Coclé	-	22.50	24.00	26.00	-

* Price plus transport costs of $75 per 100 kilograms.
Source: DINAAC

Appendix H1.--Panama. Marine shrimp farms, May 1991.

State/Company	Pond area♦
	Hectares
Coclé	
Agromarina de Panama	640#
Camaronera de Coclé##	485♦♦
Palangosta	316
La Gallinaza	200
Hacienda El Rosario	143
Melanio Aguilar	80
Cooperativa Marin Campos	77
Grupo de Salineros	75
Camaronera El Nanzal	50
Produccion y Turismo	46
Rachung	45
Belisario Medina Tuñon	36
Finca Marina Limocillo	32
Granja Marina Vargas	30
Ecydesa	29
Langostinos Rub-Car	26
Faustino Cabadas (Los Guabinos)	25
Faustino Cabadas (Bravo Mar)	25
Felipe Ramón Cedeño	25
Granja Marina (Arnulfo Franco)	25
Horacio Herrera	25
Humberto Sánchez	24
Others*	114
Total, Coclé	2,503
Panamá	
Rivoflavia	257
Aquachame	250#
Granjas Marinas	120
Grupo de Venezolanos (Gino Zane)	80
Corporación del Camarón	47
Others***	25
Total	779
Herrera	
Las Huabas	185
Sociedad Industrias Acuimar	180#
Camaronera Boca de Parita	42♦♦♦
Total, Herrera	407
Los Santos	
DECAPASA	26
Salineros de Los Santos	25
Others**	57
Total, Los Santos	108
Total	3,797

♦ Area constructed. A substantial area has been abandoned or is not currently stocked.
*8 farms
**4 farms
***2 farms
Significant discrepancies with appendix H2.
Formerly Camaronera de Nata farm.
♦♦ More recent reports from the company suggest 620 hectares.
♦♦♦ More recent information from the group suggests they operated 55 out of a total of 100 ha of ponds.
Source: Enid Rivera, provided by Armando Martínez Valdés, personal communications, May 15, 1991 and more current reports from individual farms.

Appendix H2.--Panama. Marine shrimp farms, January 1991.

State/Location	Company	Pond area♦ Extensive	Semi-int.	Total
		Hectares		
Coclé				
Aguadulce	Agromarina de Panama	-	750	750
Natá	Camaronera de Coclé#	-	485†	485†
Aguadulce	Panlangosta	-	326	326
Aguadulce	Grupo de 156 Salineros	250	-	250
Aguadulce	La Gallinaza	200	-	200
Penonomé	Hacienda El Rosario	-	175	175
Aguadulce	Melanio Aguilar	80	-	80
Aguadulce	Camarón, S.A.	80	-	80
Antón	El Nanzal	-	46	46
Antón	Belisario Medina Tuñon	-	25	25
Aguadulce	Produccion y Turismo	-	45	45
Aguadulce	Rachung	-	45	45
Aguadulce	El Chumical	35	-	35
Aguadulce	Finca Marina Limocillo	35♦♦	-	35♦♦
Antón	Granjas Marinas Vargas	-	32	32
Aguadulce	Ecydesa	-	29	29
Aguadulce	Langostinos Rub-Car	-	26	26
Aguadulce	Bravo Mar**	-	25	25
Aguadulce	Felipe Ramón Cedeño	-	25	25
Aguadulce	Coop. Salineros M. Campos	-	20	20
Aguadulce	Mando Aguilar	-	20	20
Aguadulce	Horacio Araúz	-	16	16
Aguadulce	Fernando Vargas	-	15	15
Aguadulce	Camaronera Trinidad	-	15	15
Various	Others*	NA	NA	NA
Total, Cocle		680	2,120	2,800
Panamá				
El Líbano, Chame	Aquachame	-	650	650
Bejuco, Chame	Granjas Marinas	-	120	120
Felipillo	Grupo de Venezolanos*	-	30	30
Total, Panamá		-	800	800
Herrera				
Parita	Las Guabas	-	80	80
Parita	Acuimar	-	120	120
Boca de Parita	Guacamayón	70	-	70♦♦♦
Boca de Parita	Parita	-	65	65
Total, Herrera		70	265	335
Los Santos				
Guararé	Salineros del Area de Guararé	110	-	110
Guararé	Salineros de Los Santos	-	95	95
Santa Ana	Coop. Che Paulito	80	10	90
Monagre	DECAPASA***	-	32	32
La Hondita	La Hondita de Oro	-	15	15
Guararé	Zarzavilla	-	6	6
Total, Los Santos		190	158	348
Total		940	3,343	4,283

♦ In production
♦♦ Some reports suggest that these are semi-intensive ponds. Cornelio Lara, Gerente, Finca Marina Limocillo, personal communication, December 31, 1991.
♦♦♦ More recent information from the group suggests they operated 55 out of a total of 100 ha of ponds.
† More recent reports from the company indicated 620 hectares.
# Formerly Camaronera de Natá.
* Gino Zane
** Faustino Cabadas
*** Desarrollo Camaronero del Pacífico, S.A.
Source: DINAAC

Appendix I1. -- Panama. Shrimp hatcheries, 1989.

Company	Capacity	Location	Initiated	Production system
	Million pl per month		Year	
Marine				
Aquachame	15	Chame, PA	1987	Vessel/maturation
Agromarina	30	Veracruz, PA	1974	Vessel/maturation
Camaronera de Nata (CANASA)	15♦	San Carlos, PA	1985	Vessel/maturation
(Corporacion) Agromar	15	Chame, PA	1986	Vessel/maturation
Granjas Marinas	7	Punta Chame, PA	1985	Nauplii
DINAAC/MDP*	1	Vacamonte, PA	1984	Research
Palangosta	7	Aguadulce, CO	NA	NA
Freshwater				
DINAAC*	Negl	Carrasquilla, PA	1982	Research
Total	90			

Provinces: CO - Coclé
PA - Panamá
DINAAC - Dirección Nacional de Acuicultura
MDP - Maricultura del Pacifico
* Government hatchery
♦ CANASA has been purchased by COMACO, which has modernized the hatchery and reports a monthly production of 20 million postlarvae. Alberto Villageliu, Executive Vice President, Companía Azucera Estrella (CAE), personal communication, January 8, 1992. CAE is part of a financial group which owns the COMACO farm.
Note: Differences with appendix I2 are due to the time period covered and the opening of the new Pacific Larva Centre in 1991.
Source: Dirección General de Recursos Marinos, Ministerio de Comercio e Industrias. Diagnóstico Global de la Actividad Pesquera en Panamá. Panamá 1990. p. 143 as cited by DINAAC and scattered additional reports.

Appendix I2. -- Panama. Marine shrimp hatcheries, 1991-92.

Company	Capacity	Location
	Million pl per month	
Aquachame	20-25	Punta Chame
Agromarina	30	Veracruz
Agromarina*	NA	NA
Camaronera de Coclé	15-20	San Carlos
Corporacion Agromar	10-15	Punta Chame
Granjas Marinas	10-15	Bejuco
DINAAC/MDP**	NA	Vacamonte
PACPL*	NA	Panama
Palangosta	5-10	Aguadulce
Pacific Larva Centre#	NA##	Panama
Total	150-175	

* Planned
** Government hatchery
# Opened June 1991
PLC produces nauplii. Initial runs have totaled 2-3 million nauplii per day which the company hopes to increase to 4 million pl per day once the initial phase of the project is completed. Eventually the company hopes to increase production to 210-240 million nauplii per month.
Note: Differences with appendix I2 are due to the time period covered and the opening of the new Pacific Larva Centre in 1991.
Source: William More, Agromarina, personal communications, April 10, 1991. Armando Martínez Valdés, OLDEPESCA, personal communications, May 15, 1991. Paul D. Maugle, PDM Associates, personal communications, May 22, 1991. Alberto Villageliu, Executive Vice President, Companía Azucera Estrella (CAE), personal communication, January 8, 1992.

Appendix J1.--Panama. Cost of collecting wild shrimp* postlarvae

Item	Cost
	US$ per 1,000 pl
Salaries	0.10
Transportation	
Vehicle	0.05
Other	Negl
Fuel	0.10
Outboard motors	Negl
Lubrication	0.03
Tank transporter	Negl
Oxygen	
Clinders	Negl
Gas	0.10
Manometers	Negl
Porous stones	Negl
Rotenona	0.03
Collection nets	Negl
Trawls	0.01
Mangueras/oxygen	0.01
Total	0.55

Note: The above calculations are based on the average collection of about 25 million pl and collectors working 15 days per month.
The production unit for the above costs are four individuals working an 8-hour day.
* P. stylirostris and P. vannamei.
Source: Biólogo Miguel de León, Aguadulce, Coclé as cited by DINAAC.

Appendix J2.--Panama. Theoretical postlarvae demand*, 1.0 harvests per year

Area	Stocking densities				
	5pl/m^2	10pl/m^2	15pl/m^2	20pl/m^2	25pl/m^2
Hectares			Billion pl		
1,000	0.07	0.13	0.20	0.26	0.33
2,000	0.13	0.26	0.39	0.52	0.65
3,000	0.20	0.39	0.59	0.78	0.98
4,000	0.26	0.52	1.04	1.04	1.30
5,000	0.33	0.65	0.98	1.30	1.63
6,000	0.39	0.78	1.18	1.56	1.95
7,000	0.45	0.91	1.38	1.82	2.28
8,000	0.52	1.09	1.56	2.08	2.60
9,000	0.59	1.17	1.76	2.34	2.93
10,000	0.65	1.30	1.95	2.60	3.25

* Calculations based on a 30 percent mortality rate.
Note: the above calculations are rough estimates to show approximate pl demand at various pond areas and stocking densities.
Source: NMFS estimates.

Appendix J3.--Panama. Theoretical postlarvae demand*, 2.0 harvests per year

Area	Stocking densities				
	$5pl/m^2$	$10pl/m^2$	$15pl/m^2$	$20pl/m^2$	$25pl/m^2$
Hectares			Billion pl		
1,000	0.13	0.26	0.39	0.52	0.65
2,000	0.26	0.52	0.78	1.04	1.30
3,000	0.39	0.78	1.18	1.56	1.95
4,000	0.52	1.04	1.56	2.08	2.60
5,000	0.65	1.30	1.95	2.60	3.25
6,000	0.78	1.56	2.36	3.12	3.90
7,000	0.91	1.82	2.75	3.64	4.55
8,000	1.04	2.08	3.12	4.16	5.20
9,000	1.17	2.34	3.51	4.68	5.85
10,000	1.30	2.60	3.90	5.20	6.50

* Calculations based on a 30 percent mortality rate.
Note: the above calculations are rough estimates to show approximate pl demand at various pond areas and stocking densities.
Source: NMFS estimates.

Appendix J4.--Panama. Estimated postlarvae demand*

Year	Pond area	Stocking densities	Annual harvests	Demand
	Hectares	Pl/m^2	Number	Billion pl
1985	2,499	5	1	0.2
1986	3,013	6	1	0.2
1987	2,847	7	1	0.3
1988	3,531	8	1	0.4
1989	3,718	9	1	0.4
1990	NA	NA	1	NA
1991	4,200	10	1	0.5

* Calculations based on a 30 percent mortality rate.
Note: the above calculations are rough estimates to show approximate pl demand, based on available information on growout operations.
Source: NMFS estimates

Appendix J5.--Panama. Agromarina prices, May 20, 1991

Stage	Price
	US$ per 1,000
Nauplii	1.50*
Postlarvae**	
Pl 6-7	8.50
Pl 7-8	10.00
Pl 8-9	10.75
Pl 9-10	11.50

* $1.25 for clients under contract. Maximum 250,000 per bag.
** Maximum 40,000 pl per bag.
Note: Nauplii and pl generally available year-round. Shipped in double plastic bags with 8 l of saltwater. Two bags per styrofoam box. Acclimated to 20°C. The boxes weigh 20 kg (net) and 25 kg (gross). Prices (ex plant) are approximate and subject to change.
Source: Jorge Pang, Agromarina, personal communication, May 20, 1991, as cited in item 16.9.25 World Shrimp Farming, September 1991, p. 21.

Appendix K1.--Panama. Shrimp exports, 1986-89

Destination	Product form		Total
	Raw*	Cooked	
	1,000 Metric Tons**		
United States	31.6	Negl	31.6
Europe	0.7	0.4	1.1
Canada	0.8	Negl	0.8
Central America	Negl	Negl	Negl
Caribbean	Negl	Negl	Negl
South America	Negl	Negl	Negl
Total	33.1	0.4	33.5

* Mostly frozen, but small amounts of fresh product
** Product weight
Source: Dirección de Informática, Instituto Panameño de Comercio Exterior (IPCE), Panamá, 1991 as cited by DINAAC.

Appendix K2.--Panama. Shrimp exports, 1986-89

Destination	Product form		Total
	Raw*	Cooked	
	US$ Million		
United States	237.4	0.1	237.6
Europe	4.2	2.8	7.0
Canada	6.0	-	6.0
Central America	Negl	Negl	Negl
Caribbean	0.1	Negl	0.1
South America	0.1	Negl	0.1
Total	247.8	2.9	250.7

* Mostly frozen, but small amounts of fresh product
Source: Dirección de Informática, Instituto Panameño de Comercio Exterior (IPCE), Panamá, 1991 as cited by DINAAC.

Appendix K3.-- Panama. Shrimp exports by country, 1980-90

Year	Country			Total	U.S. share
	U.S.	E.C*	Japan		
	1,000 Metric Tons**				Percent
1980	6.2	0.1	-	6.3	98
1981	7.2	0.2	-	7.4	97
1982	8.0	0.1	-	8.1	99
1983	7.4	0.1	-	7.5	99
1984	7.4	Negl	-	7.4	100
1985	8.9	0.2	-	9.1	98
1986	9.9	0.1	-	10.1	98
1987	7.5	0.2	-	7.7	97
1988	6.7	0.4	-	7.1	94
1989	7.8	0.5	-	8.3	94
1990	5.3	0.7	-	6.0	88
1991	5.8E♦	NA	NA	NA	NA

* Includes Spanish data beginning in 1986.
** Product weight
♦ Extrapolated from data available through October.
Sources: U.S. Bureau of the Census, EC NIMEXE, and the Japan Tariff Association.

Appendix K4.--Panama. U.S. shrimp imports, 1980-90

Year	Imports	
	Quantity	Value
	Metric tons*	US$ Million
1980	6,227	46.2
1981	7,223	55.4
1982	7,990	61.2
1983	7,373	58.7
1984	7,400	61.6
1985	8,919	67.8
1986	9,885	77.8
1987	7,537	69.7
1988	6,685	57.6
1989	7,804	68.5
1990	5,318	41.1
1991	5,926	47.2

* Product weight
Source: U.S. Bureau of the Census.

Appendix K5.--Panama. U.S. shrimp imports by product form and size count, 1990

Product/ Size	Imports	
	Quantity	Value
	Metric tons	US$ Million
Fresh	14.5	0.2
Frozen		
Shell-on		
Under 15*	428.9	6.2
15/20*	133.6	1.6
21/25*	130.1	1.4
26/30	209.3	1.3
31/40**	323.1	2.4
41/50	205.7	1.3
51/60	256.5	1.4
61/70	112.5	0.5
over 70	141.3	1.0
Unclassified♦	2,333.0	18.4
Peeled	895.6	4.9
Breaded	133.2	0.5
Total#	5,317.3	41.1

* Primarily trawler caught.
** Primarily pond harvested.
♦ Shrimp imported from January to June were not recorded by size count.
Totals may not agree due to rounding.
Note: Recording imports by size count was introduced in July 1990. As a result, some problems still exist in collecting and processing the information. As a result, the above data should be used with some reservation.
Source: U.S. Bureau of the Census.

Appendix K6.--U.S. Breaded shrimp imports, 1990

Country	Imports	
	Quantity	Value
	Metric tons	US$1,000
Panama	**133.2**	**528**
Philippines	7.1	57
Canada	1.5	7
Japan	4.0	5
Taiwan	0.2	2
Total	146.1	598

Source: U.S. Bureau of the Census

Appendix K7.--EC. Shrimp imports from Panama, by importing country,1980-90

Country	Year				
	1986	1987	1988	1989	1990
	Metric tons				
Spain	5	68	312	414	606
Portugal	-	4	-	-	58
Italy	-	9	6	5	7
Netherlands	35	16	15	72	-
France	77	108	58	4	-
Belgium/Lux.	-	-	13	-	-
Germany	1	-	-	-	-
Total	118	205	404	495	671

NA - Not available
Source: EC NIMEXE

Appendix K8.--United States. Shrimp prices (31-40 count), May 3, 1991

Country/type	Price	Primary source
	US$/lb	
Whites		
U.S. (Gulf)	5.35	Trawler
Mexico		
No. 1	5.15	Trawler
No. 2	4.95	Trawler
Ecuador	4.80	Pond
China No. 1	4.05	Pond
Panama	4.80	Mixed
Black Tigers		
China	3.90	Pond
Thailand	3.95	Pond

Source: NMFS Fisheries Market News Report, May 3, 1991.

Appendix K9.--Japan. Shrimp imports from Latin American countries, 1980-90

Country	Exports										
	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
	1,000 Metric Tons										
Brazil	2.7	1.9	2.5	1.5	1.8	2.4	1.7	1.8	2.0	1.9	2.0
Colombia	0.4	0.3	0.3	0.4	0.5	0.8	1.0	1.3	1.4	1.2	1.4
Mexico	3.4	3.1	3.9	3.1	2.2	2.0	1.8	1.7	1.7	1.5	1.3
Suriname	1.3	1.7	1.1	0.9	0.7	0.7	1.7	1.8	1.3	1.0	1.0
Guyana	1.0	0.8	0.8	0.8	0.4	0.3	0.3	0.4	0.3	0.3	0.2
Argentina	-	-	1.6	4.8	4.5	5.4	1.2	0.1	3.3	0.5	-
French Guiana	0.2	Negl	Negl	Negl	-	-	-	-	-	0.2	-
Ecuador	Negl	0.2	0.4	1.0	0.7	0.4	0.2	0.1	0.1	0.1	-
Venezuela	0.2	Negl	-	Negl	Negl	Negl	Negl	-	-	Negl	-
Cuba	0.6	0.5	0.7	0.6	0.2	-	Negl	0.2	0.4	-	-
Total	9.8	8.5	11.3	13.1	11.0	12.0	7.9	7.4	10.5	6.7	5.9

Negl - Negligible, less than 50 metric tons.
Source: Japan Tariff Association, various years.