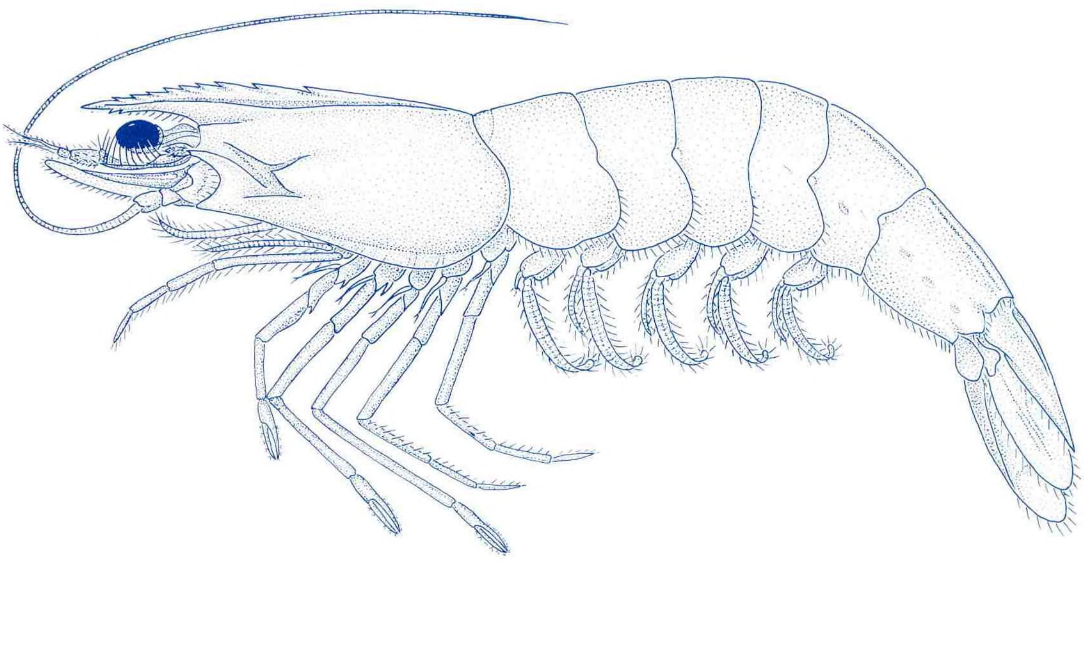
World Shrimp Culture

Volume 2, Part Three

South America



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World Shrimp Culture

Volume 2: Latin America

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SOUTH AMERICA

South American countries, which dominate the Latin American shrimp culture industry, harvested 118,000 t of cultured shrimp in 1991, about 90 percent of the nearly 140,000 t total harvested by Latin Americans. Ecuador's shrimp culture industry is by far the most important, dominating the regional harvest. The South American harvest has increased in stages, primarily due to expanding pond area in Ecuador and the periodic impact of El Niño events on the Ecuadorean harvest. The Ecuadorean industry was initiated with extensive methods. Growers throughout the region are now turning to higher-yielding semi-intensive methods. Successful growers in most countries are using a Pacific white shrimp, *P. vannamei*. Brazilian growers, however, are experimenting with a wide range of different species. Prospects for expanded production vary widely from country to country. The South American countries will continue to dominate the Latin American shrimp culture industry because of the large number of suitable sites available for development. Ecuador continues to eclipse other South American countries and harvests in that country will probably determine overall South American trends during the 1990s. Future Ecuadorean harvests, however, will probably not increase at anywhere near the rate achieved during the 1980s. The potential of the other South American countries varies. Colombia has a very substantial potential, although growers are unlikely to reach Ecuadorean levels. Peru has a relatively confined area in the northern part of the country and economic and political conditions will limit expansion plans. The real unknown in South America is Brazil, which may have the potential to produce more shrimp than the rest of South America combined. Several companies are actively culturing shrimp in Brazil, but they have not reported the same commercial success achieved by farmers along South America's Pacific coast. If and when Brazilian farmers perfect methods applicable to Atlantic-coast conditions, some very large increases in South American shrimp harvests would be possible.

I. CAPTURE FISHERY

Several South American countries conduct important capture shrimp fisheries. Brazil conducts the largest fishery and catches total 45,000-65,000 t annually (appendix A). Timely information on the large Brazilian fishery is not available, but catches since 1988 have been on the lower end of the catch range. Unconfirmed reports suggest that catches continued to decline in 1991. The Ecuadorean fishery can exceed 10,000 t annually. The Argentine fishery fluctuates wildly, but has exceeded 23,000 tons.[1] Several other countries (Venezuela, Guyana, French Guiana, and Suriname) conduct smaller fisheries, which are of some local importance. The primary target species are a variety of tropical *Penaeids*, but some smaller non-*Penaeids* are also of commercial importance.[2] The Argentine fishery is based on two coldwater non-*Penaeids*. Only three countries in South America (Colombia, Ecuador, and Peru) have access to the *Penaeid* species preferred by most Latin American growers, *Penaeus vannamei*. Only two of those countries (Ecuador and Peru), however, have been able to successfully collect wild postlarval seedstock to supply growers.[3]

II. AQUACULTURE

South American countries have very small aquaculture industries. Ecuador reports the largest cultured harvest (appendix B), but it is almost entirely marine shrimp. Chile has the largest non-shrimp cultured harvest. Much of the Chilean harvest is

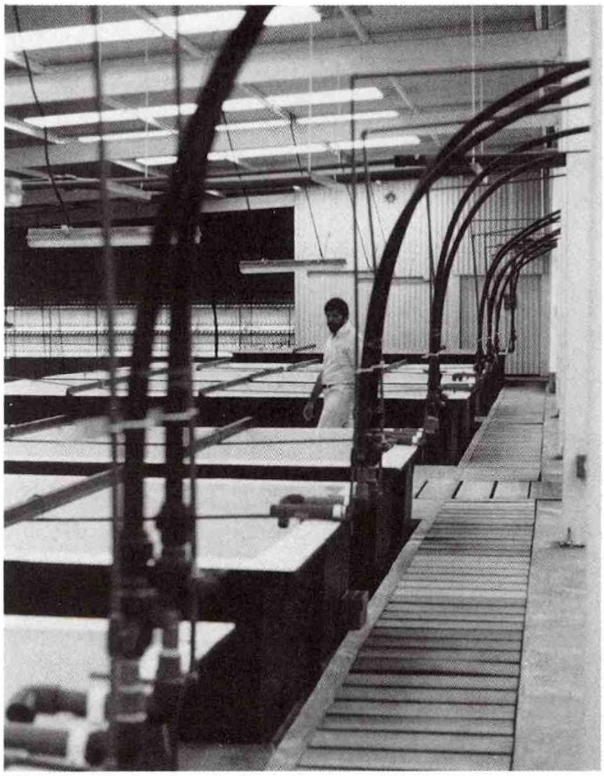

Photo 1.--The hatchery industry is centered in Ecuador, but facilities are also being built in other countries like AQUACAM in Venezuela. © *Jorge Pang, Agromarina*

salmon and the industry since 1989 has expanded significantly.[4] Chile also reports small harvests of a variety of bivalve mollusks and other species.[5] The Brazilian harvest is primarily freshwater finfish and shrimp, but observers report the development of a major frog culture industry. Two countries (Colombia and Peru) harvest small quantities of freshwater fish, but other countries report only negligible harvests of cultured species other than shrimp.

III. SHRIMP CULTURE

Most Latin American countries with the greatest potential to culture shrimp (Ecuador, Brazil, Mexico, Colombia, and Peru) are located in South America--with the exception of Mexico. Virtually all the South American countries (even land-locked Bolivia and Paraguay) are either launching shrimp culture projects or experimenting with shrimp. While most activity has been conducted along the northern coast, even the southern-cone countries (Argentina, Chile, and Uruguay) have initiated pilot commercial projects or research programs to assess the potential for culturing various shrimp species. Most South American countries are just beginning to realize their potential. Only Ecuador and Peru appear to have largely developed available sites with the best growing conditions. Ecuador alone currently has about 110,000 ha of ponds (appendix E). Colombia has developed many of the best Caribbean sites, but it still has very large undeveloped areas along its Pacific coast. Many potential Colombian Pacific-coast sites, however, are located in remote zones that will be difficult and costly to develop. The other tropical countries (Brazil, French Guiana, Guyana, Suriname, and Venezuela) have substantial areas that could prove suitable for shrimp farms. Brazil alone probably has about half of the tropical coastline in South America.

Ecuadorean growers initiated commercial development with extensive farms. Such methods proved especially successful early in the country's development. Observers point out that despite the low yields, extensive methods continue to have some advantages.[6] Many countries (Brazil and Colombia) reported difficulties, however, when they attempted to introduce Ecuadorean-style extensive methods. Many Brazilian growers continue to use extensive or semi-intensive growout methods, but results have been generally disappointing.[7] Growers throughout South America are gradually shifting to semi-intensive systems. Modern semi-intensive farms are now operating in five South American countries (Brazil, Colombia, Ecuador, Peru, and Venezuela). A few growers are also experimenting with intensive methods. While many growers are intensifying their

Photo 2.--Most of the South American cultured harvest is produced in Ecuador where many growers still use extensive methods. *Dennis Weidner*

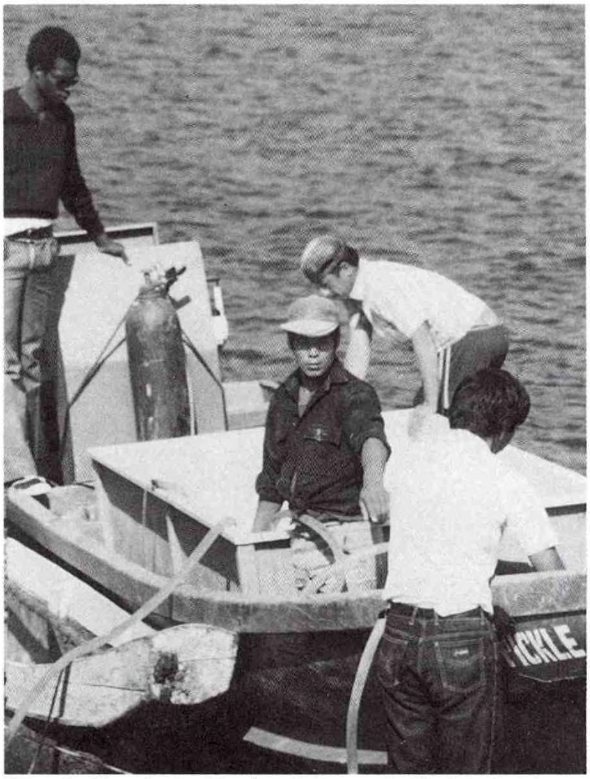

Photo 3.--Ecuador has developed an extensive logistical system to deliver huge quantities of wild pl to growers. Dennis Weidner

semi-extensive/semi-intensive farms with various innovations, only a few are attempting to implement intensive growout systems. Most South American countries (Brazil, Colombia, Ecuador, and Venezuela) have fairly large areas suitable for pond culture and suitable economic and climatic conditions for semi-intensive growout systems. As a result, there would appear to be little justification for the substantially expanded capital investments needed to build and operate an intensive farm.

South American growers face widely different growing conditions from country to country and, as result, development levels vary greatly.

Climate: South American growing conditions vary from the tropical climate of the northern-most countries of Colombia, Venezuela, and the Guianas (12-5°N) to sub-Antarctic conditions in the southern-most countries of Argentina and Chile (55°S). It is unclear how far south along the two coasts shrimp can be profitably cultured. Pacific-coast growers are currently unlikely to achieve much success south of Tumbes in northern Peru.[8] The situation is less clear along the Atlantic coast because Brazil has made so little progress in developing its shrimp culture industry. Temperature constraints, however, appear favorable as far south as Cabo Frio. Some growers believe that shrimp can be profitably cultured even further south, but such operations have not yet been conclusively demonstrated.[9] Tropical growing conditions occur much further south along the Atlantic coast than is the case along the Pacific coast (appendix C). It is thus somewhat surprising that the industry's development has occurred primarily along the Pacific coast.

El Niño: The periodic El Niño event can have a major impact on Pacific-coast growing conditions, especially in Ecuador, Peru and Colombia. The impact is generally positive, creating abundant seedstock and favorable growing conditions. The heavy rains often associated with El Niño events, however, can damage ponds.[10] Current reports suggest that the latest (1991-92 El Niño) ended in mid-1992.

Coasts: Colombia has both a Caribbean and Pacific coast, all of the other South American countries have coasts on either the Atlantic/Caribbean or Pacific. While variations in growing conditions exist along the two coasts, the major limiting factor along the Atlantic has probably been the absence of a species which performs as well as Pacific-coast species, especially *P. vannamei*. This has had a massive adverse impact on the industry's development and has meant in effect that growers (with the exception of Colombia) have been unable to significantly utilize more than half of South America's tropical coast.

Seedstock: The industry's dependence on wild seedstock during the 1980s has been the primary

Photo 4.--Most growers stock P. vannamei, but Atlantic coast growers, especially in Brazil, are trying other species such as P. subtilis. © Itamar Rocha, MCR

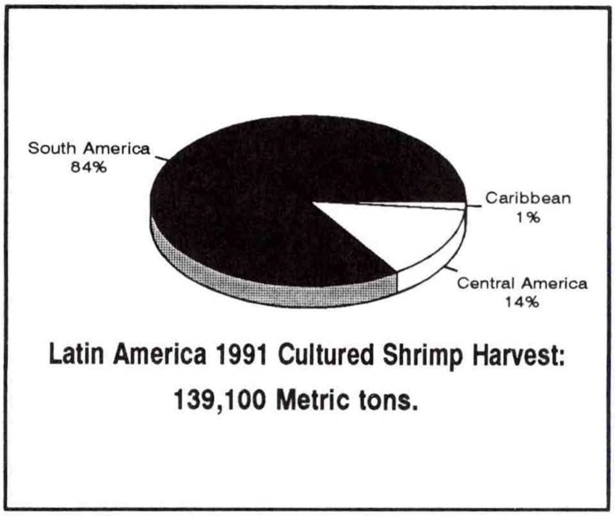

Figure 1.--The great bulk of Latin American cultured shrimp is produced in South America.

factor limiting development to the Pacific coast. The abundance of wild pl has enabled Ecuador to collect massive quantities of seedstock.

Species: The superior performance in ponds of a Pacific white shrimp (*P. vannamei*) has proven a major factor in the success of farms in Ecuador and other Pacific-coast countries. The inability of Atlantic-coast growers, on the other hand, to identify a species that performed well in ponds has sharply curtailed the industry's development there. Several Atlantic/Caribbean countries (especially Cuba and Brazil) are doing considerable work on alternative species.[11] Growers are optimistic about some indigenous species (especially *P. schmitti* and *P. subtilis*). Other observers, however, believe that two decades of work in the region suggest that these species are just not as well suited for culture as *P. vannamei*. Freshwater shrimp (*Macrobrachium rosenbergii*) is important in some countries (Brazil and French Guiana). Brazilian growers in particular are optimistic about freshwater shrimp culture.[12]

Government policy: The industry's development even in Ecuador has been impaired by adverse macroeconomic policies. Several countries pursued economic programs during the 1980s which restricted exports and discouraged foreign investment. Ecuador, for example, imposed a major tax on exporters through its exchange rate policy. The Brazilian Government during the 1980s initiated a shrimp culture promotion program, but it was not well administered and the results were disappointing. Colombia has implemented the most effective government promotional program. While it has achieved considerable success, new government policies are reducing support levels.

South America dominates the Latin American shrimp culture industry. South American countries harvested about 118,000 t of cultured shrimp in 1991 (appendix C). About 90 percent of the nearly 140,000 t of cultured shrimp harvested by Latin Americans in 1991 came from South America (figure 1). Ecuador continues to overshadow other South American countries with its massive harvests.[13] South American harvests have increased in stages, primarily due to expanding pond area in Ecuador and the periodic impact of El Niño events on the Ecuadorean harvest. Each major increase in the South American harvest (1983, 1987, and 1991) occurred either during or immediately following an El Niño event (figure 2).[14] Despite Ecuador's continued importance, other countries are steadily increasing their share of the overall cultured harvest.

Prospects for expanded production vary widely from country to country. The South American countries will continue to dominate the Latin American shrimp culture industry because of the much larger area of suitable sites available in those countries. Ecuador continues to provide most of the South American harvests and, as a result, developments in that country will largely determine overall South American trends during the 1990s. Reports from Ecuador suggest that growers have now developed most of the best sites. Further increases will have to come primarily from intensifying operations at existing sites. While detailed information is not available, Ecuadorean growers do not appear to be making a major effort to intensify

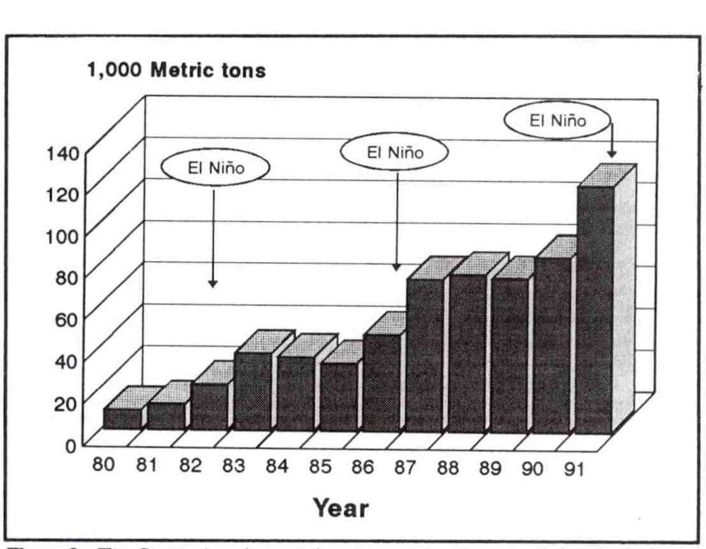

Figure 2.--The South American shrimp harvest has increased sharply during or following each El Niño event.

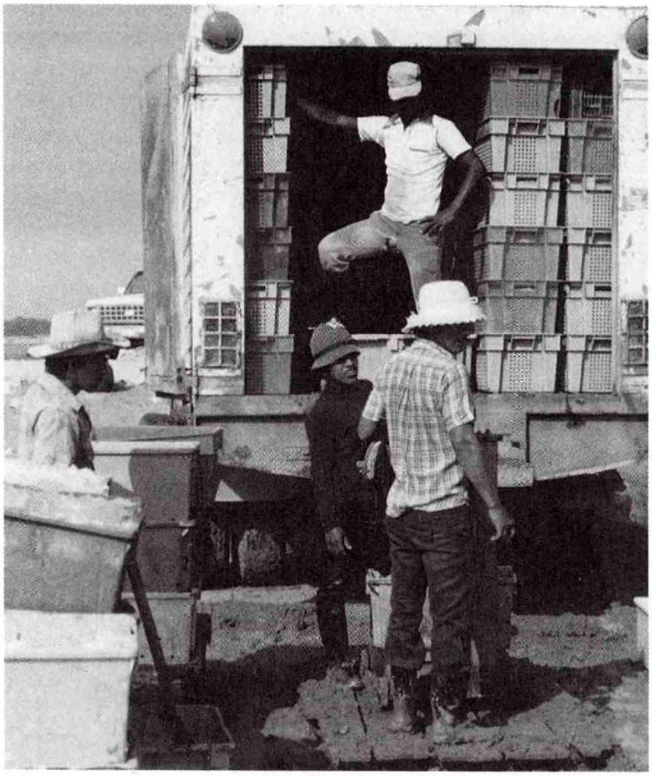

Photo 5.--Ecuadorean harvests will continue to dominate South American cultured shrimp production during the 1990s, but other countries are becoming more important. D. Weidner

their growout systems.[15] Future Ecuadorean harvests will therefore probably not increase anywhere near the rate achieved during the 1980s. The potential of the other South American countries varies. Colombia has a very substantial potential, although growers there are unlikely to reach Ecuadorean harvest levels. Peru has a relatively limited area in the northern part of the country and economic and political conditions in the country are limiting investor expansion plans. Guyana and Suriname could culture shrimp, but the economic and political situation in both countries is also inhibiting investor interest. French growers in French Guiana could culture marine shrimp and technical assistance is available through France-Aquaculture. The French have, however, concentrated on freshwater shrimp. Significant production in the southern cone countries (Argentina, Chile, and Uruguay) or the land-locked countries (Bolivia and Uruguay) during the 1990s is unlikely. The key unanswered question in South America is Brazil which, in the long run, will determine the full capability of South American growers. Brazil may have the potential to produce more shrimp than all the rest of South America combined. Several companies are actively culturing shrimp in Brazil, but they have not reported the same commercial success achieved by farmers along South America's Pacific coast. If and when Brazilian farmers perfect methods applicable to Atlantic-coast conditions, some very major increases in South American shrimp harvests would be possible.

The difficulties experienced in Brazil and other Atlantic/Caribbean coast farms are in large part caused by the poor performance of indigenous species. As a result, there are few commercially successful farms anywhere along the Caribbean or Atlantic coast. The only major exception is Colombia and that is primarily because Colombian Caribbean-coast growers were able to obtain access to Pacific-coast seedstock.[16] Other Atlantic-coast South American growers were unable to obtain suitable seedstock. Growers have thus not been able to utilize more than half of the South American tropical coast. Some characteristics along the Atlantic coast are actually more favorable than the Pacific. The cold Humboldt Current, for example, prevents tropical shrimp farming south of northern Peru (appendix C). This significantly limits the area of the Pacific coast suitable for pond culture. Along the Atlantic coast, however, climatic conditions are favorable at latitudes much further south. The expansion of hatchery industries may mean that Atlantic coast growers will be able to obtain regular supplies of increasingly high-quality *P. vannamei* seedstock at reasonable prices. As a result, the success of Colombian growers along the Caribbean coast during the 1980s could eventually be repeated in other South American countries (especially Brazil and Venezuela).

SOURCES

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ENDNOTES

SECTION I (Capture Fishery)

1. For details see Dennis Weidner, "Argentine Shrimp Fishery, 1985" *International Fishery Reports*, (IFR-85/17), May 9, 1985.

2. Specific details on the species are available in the individual country reports.

3. Although *P. vannamei* occurs off the Colombian Pacific coast, growers there have not been able to organize an effective collection system. Dennis Weidner and Tom Revord, "Colombian Shrimp Culture," *International Fishery Reports*, (IFR-91/90), December 15, 1991.

SECTION II (Aquaculture)

4. For details see William Folsom, Eleanor Sanborn, and Tom Revord, "Chile," *World Salmon Culture* (NMFS: Silver Spring, Maryland, 1992).

5. Chile also has a substantial seaweed harvest, but it is not included in appendix B.

SECTION III (Shrimp Culture)

6. Growers encounter a variety of pond management problems as they intensify operations. Bob Rosenberry, personal communications, May 25, 1992.

7. For details see Dennis Weidner, "Brazilian Shrimp Culture," *International Fishery Reports*, (IFR-90/92), December 21, 1991.

8. A few farms have been built further south in Piura Province, but it is not yet known if these farms will prove successful. Tom Revord and Dennis Weidner, "Peruvian Shrimp Culture," *International Fishery Reports*, (IFR-91/91), December 6, 1991.

9. For details on the industry's development in the country's various regions, see Dennis Weidner, "Brazilian Shrimp Culture," *International Fishery Reports*, (IFR-90/92), December 21, 1990.

10. The author traveled along the coast of Southern Ecuador (Salinas) south to northern Peru (Paita) during late 1983. The damage to the coastal highway system as a result of the massive 1982-83 El Niño was catastrophic. Highways and bridges were devastated. The 1991-92 El Niño has been much more moderate. The rains at first (December 1991-February 1992) helped clean out ponds and reduce levels of organic material. The torrential rains during mid-March 1992, however, did substantial damage. Reports from both

Ecuador and Peru indicate substantial flood damage. The floods washed away ponds, damaged pumps and generators, allowed whole crops to escape pond enclosures. Early damage estimates exceed $30 million, but are still being evaluated. Most growers insured their farms as a result of $60 million in damage during the major 1982-83 El Niño. Repairs can not begin until the ground drys out during the dry season. "Floods hit ponds in Peru," *Fish Farming International*, May 1992, p. 2.

11. For details see Weidner, "Brazilian Shrimp Culture," *op. cit.* and Dennis Weidner and Randolf Wells, "Cuban Shrimp Culture," *International Fishery Reports*, (IFR-92/32), May 31, 1992.

12. Some observers report that freshwater shrimp growers are achieving some success. About 700 ha of ponds were in operation during 1991 and another 100 ha were under construction. Growers report yields of about 1.5 t per ha and sales of about $7 per kilogram. The expanding growout are is increasing demand for postlarval seedstock. One report suggests that 30 small freshwater shrimp hatcheries were operating in early 1992 and several new hatcheries were under construction. The hatcheries report pl sales of about $12 per 1,000. Itamar Rocha as cited in "Freshwater Prawn Hatcheries Expansion in Brazil," *Larviculture & Artemia Newsletter*, December, 1991, p.26.

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

14. The relationship between cultured harvests and El Niño events is described in Revord and Weidner, "Ecuadorean Shrimp Culture," *op. cit.*

15. Revord and Weidner, "Ecuadorean Shrimp Culture," *op. cit.*

16. Interestingly, the Colombian Caribbean-coast farms are some of the most successful in Latin America. For details see Revord and Weidner, "Colombian Shrimp Culture," *op. cit.*

APPENDICES

Appendix A.--South America. Total shrimp harvests (wild caught and cultured) 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
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
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
Guyana	2.0	2.1	2.0	2.0	2.4	3.2	3.1	2.9	3.7	3.8	3.9	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
Suriname	0.8	1.0	0.7	0.7	0.8	0.6	0.7	1.1	0.7	0.7	0.8	NA
Uruguay	-	Negl	-	-	Negl	Negl	Negl	Negl	Negl	Negl	Negl	NA
Total	94.9	84.4	108.4	143.9	146.8	137.4	141.0	169.1	181.7	180.7	189.0	NA

* Liveweight equivalent
** Much of the catch off French Guiana during the early 1980s was taken by foreign-flag fishermen.
# Mostly cultured
Mostly wild catch
E - Estimate
NA - Not Available
Negl - Negligible
Note: The above data includes both cultured and wild-capture fisheries. The approximate dimensions of the capture fishery can be determined by using the 1980 column before massive cultured harvests were reported. Only Ecuador reported a cultured harvest (9,200 t) in 1980, as a result the Ecuadorean wild catch was about 7,800 tons.
Source: FAO, Fishery Statistics Yearbook, various issues.

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

Region/Country	Year				
	1985	1986	1987	1988	1989
	1,000 Metric tons				
Ecuador	30.2	30.7	73.9	75.6	73.1F
Chile*	2.6	4.6	4.8	9.2	15.3
Brazil♦	11.5	11.6	13.6	13.9	13.9
Colombia	1.6	3.1R	3.3R	5.5	5.7F
Peru	7.5	2.7	4.4F	5.1F	5.0F
Bolivia	NA	NA	Negl	Negl	1.0
Venezuela	0.8	0.4	0.6	0.6	0.6R
Argentina	0.2	0.2	0.3	0.4	0.4
French Guiana♦	Negl	Negl	0.1	0.1	0.1
Guyana	Negl	0.1	Negl	Negl	0.1
Paraguay	NA	NA	Negl	0.1	0.1F
Suriname	-	-	-	-	-
Uruguay	-	-	-	-	-
Total	59.3F	53.4F	10.1F	110.5F	115.3F

F - FAO estimate
* Excludes seaweed.
♦ Freshwater shrimp harvest important
Source: FAO, "Aquaculture Production (1986-89)," FAO Fisheries Circular No. 815, Rev. 3, July 1991 and previous issues.

Appendix C.--South America. Sea surface temperatures, 1989-91.

Year/ Month	Pacific Northern Peru	Pacific Southern Ecuador	Pacific Colombia	Atlantic Colombia	Atlantic Brazil Northeast	Atlantic Brazil South
	Degrees Celsius					
1989						
January	21	23	26	27	27	23-25
February	23	24	24	26	27	24-26
March	23	25	26-28	27	26	22-26
April	23	25	27	27	26	20-25
May	19	21	26-27	28	27-28	18-24
June	20	24	26-27	27-28	27	15-18
July	20	22	26-27	28	27-28	NA
August	19	23	26-28	29	26-27	15-22
September	18	22	26-28	29	27	14-20
October	19	23	26-28	29	27	16-21
November	19	22	26-27	28	27-28	19-22
December	21	25	26-27	28	27	21-24
1990						
January	22	25	26-27	27	27	21-24
February	22	25	26	26-27	27	24-26
March	23	26	27-29	26-27	27	24-26
April	21	24	26-27	26-27	27	22-25
May	22	25	27-28	28-29	28	19-24
June	21	24	27-28	28-29	27	15-23
July	20	24	26-28	28-29	27	15-22
August	20	25	25-28	28	25-27	14-21
September	21	25	25-28	29	25-27	12-18
October	19	22	25-27	28	26-27	18-22
November	20	22	25-28	28	26-27	18-23
December	21	22	26-27	27	27	
1991						
January	23	24	26-27	27-28	27	23-26
February	25	26	26	26-27	27	23-25
March	24	25	27	27	27-28	23-25
April	23	24-25	27-28	27-28	28-29	20-25
May	22	24	27-28	27	28	19-24
June	21	25	27-28	27-29	27-28	15-24
July	20	24	27-28	27-28	26-27	13-22
August	20	24	27-28	27-28	26-27	14-20
September	19	23	26-27	28	25-26	14-20
October	20	25	26-28	28	26-27	15-21
November	20	25	27	28	27	18-23
December	21	24	27	27	27	22-25

Note: Temperatures are approximations based on visual estimates from map graphics.
Source: Climate Analysis Center. National Weather Service, NOAA. TOGA Analysis.

Appendix D.--South America. Shrimp culture harvests, 1980-1991

Region/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	70.0	100.0E
Colombia	-	-	-	-	Negl	0.1	0.2	0.5	1.3	3.0	6.0	9.8
Peru	NA	NA	NA	0.6	1.0	1.1	1.2	2.0	2.3	4.0	5.0	5.5E
Brazil♦	-	-	Negl	0.1E	0.2E	0.4E	0.5E	0.5E	0.8E	1.3E	1.7E	NA
Guyana	-	-	Negl	Negl	Negl	Negl	0.1	Negl	NA	Negl	Negl	Negl
French Guiana♦	-	-	-	Negl	Negl	Negl	Negl	0.1	0.1	0.1	0.1	NA
Suriname	-	-	-	-	-	-	-	Negl	Negl	Negl	Negl	NA
Argentina	-	-	-	-	-	-	Negl	Negl	Negl	Negl	Negl	Negl
Uruguay	-	-	-	-	Negl	Negl	Negl	Negl	Negl	Negl	Negl	Negl
Bolivia	-	-	-	-	-	-	-	-	-	-	-	-
Chile	-	-	-	-	-	-	-	-	-	-	-	-
Paraguay	-	-	-	-	-	-	-	-	-	-	-	-
Venezuela	-	-	-	-	Negl	Negl	Negl	Negl	Negl	0.1	0.2	NA
Total	9.2	12.1	21.6	36.5	34.9	32.0	45.8	72.5	74.8	72.9	83.2	117.5E

♦ 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 E.--South America. Shrimp culture industry overview, 1991*

Country	Proportion cultured	Harvest	Ponds*	Yield	Hatcheries	Farms	Comment
	Percent	Metric tons	Hectares	Tons/ha	Number		
Argentina	1	30P	50	1.7	2	2	Mostly freshwater
Bolivia	NA	-	-	NA	-	-	No marine coast
Brazil♦	3	2,500E	3,850	0.6	35#	30	Vast potential
Chile	-	-	-	NA	-##	-	Research only
Colombia	60	9,800	2,900	1.4	20	30	Harvests increasing
Ecuador	95	100,000E	110,000	0.9	230	1,400•	Consistent producer
French Guiana♦	3	80E	46	1.8	1	5	Freshwater only
Guyana	1	40	-+	0.2	-	-+	Artisanal harvests
Paraguay	-	-	-	NA	-	-	No marine coast
Peru	90	5,500	2,100	1.5	3	70	Limited area
Suriname	-	-	-	NA	-	2	Limited trials
Uruguay	-	-	-	NA	-	1	Limited research
Venezuela♦	3	240	515	0.5	3	5	Slow permit progress
Total	NA	118,193	119,461	NA	294	1,545	

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.
• Some reports are as high as 1,700.
♦ 1990 data
\+ Shrimp is harvested from pond enclosures, but only incidentally with finfish and other species.
Source: Various country reports.

4.1

ARGENTINA

Argentina has not yet developed a shrimp culture industry. The temperate climate and absence of an indigenous marine species suitable for pond culture suggest that the potential is limited. Some Argentines, however, believe that a freshwater shrimp culture industry can be developed and commercial projects are underway. Argentine researchers have conducted some limited research. Despite current efforts, it is unlikely that Argentina will develop an important shrimp culture industry during the 1990s. Limited success with freshwater shrimp is possible, but harvests are unlikely to exceed 1,000 metric tons by 2000.

CONTENTS

I. CAPTURE FISHERY

Argentina initiated a substantial shrimp fishery in the early 1980s. It is conducted along the central coast in the Gulf of San Jorge (43°-47°10´ South) (figure 1). Catches fluctuate sharply from year to year (appendix B). While the country's fishing industry primarily focuses on hakes, the value of shrimp catches in some years have exceeded that of hake.[1] Unlike most other Latin American countries, however, the fishery is not based on tropical *Penaeid* species. The primary species taken is Argentine red shrimp (*Pleoticus muelleri*[2]), and smaller quantities of stiletto shrimp (*Artemesia longinaris*).

II. POTENTIAL

Argentina has made little progress toward developing a shrimp culture industry, but some basic research has been conducted and a few commercial ventures are underway. Two factors (climate and species) suggest that the development of a shrimp culture industry will proceed slowly for the foreseeable future.

Climate: The country's temperate climate probably precludes either extensive or semi-intensive culture of fast-growing tropical shrimp. Average temperatures near Buenos Aires range from 10-23°C (appendix C). Annual precipitation averages slightly over 100 centimeters in the Buenos Aires area. While shrimp could be cultured in northern Argentina, the temperate climate will limit yields and Argentine growers would have difficulty competing with other growers in tropical countries. The limited available research confirms that growth rates will be less than those achieved for tropical shrimp in more northerly Latin American countries.

Species: The suitability of indigenous species for culture is still largely unknown. Some limited work has been done on indigenous species, but local growers will not be able to draw on the considerable body of information on tropical *Penaeid* shrimp culture. Experts from the major research institutes reviewed the Argentine aquaculture potential in 1990 and focused on *P. muelleri* and *M. rosenbergii* as the most appropriate shrimp species.[3] One researcher is working on Argentine grass shrimp (*Palaemonetes argentinus*).[4]

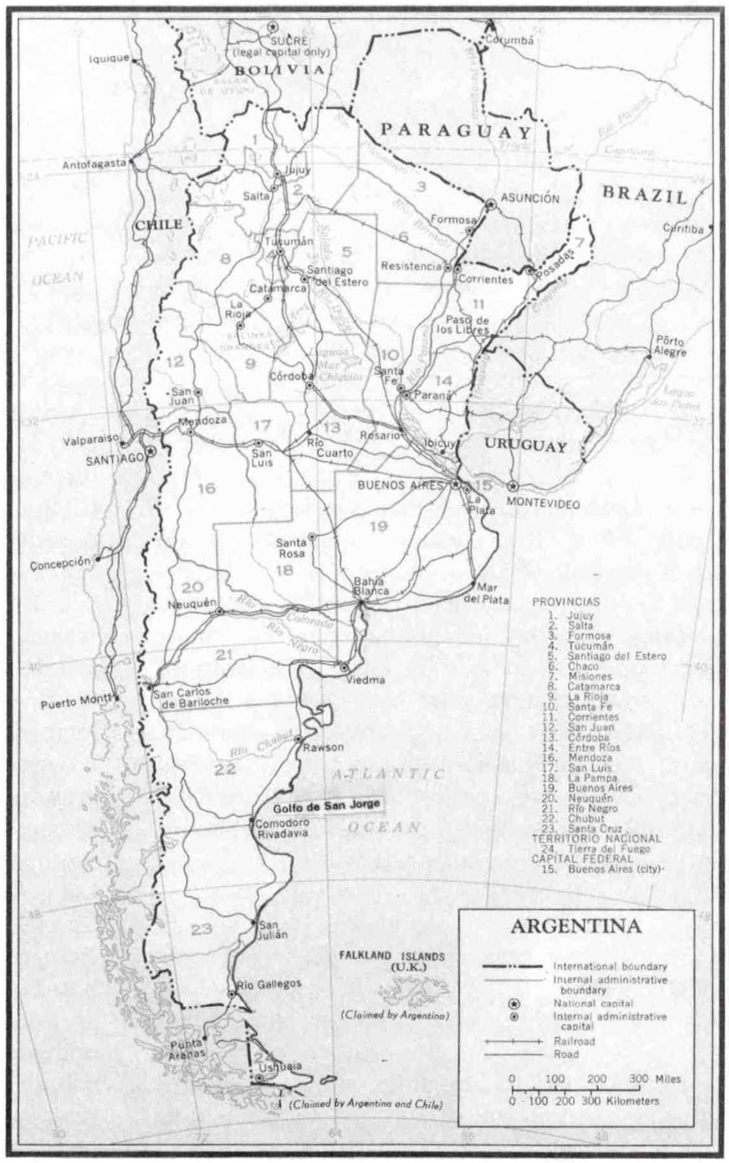
III. RESEARCH

The Fundación Pablo Cassará in 1990 founded an Aquaculture Reference Center. The center is assisting researchers with reference searches on foreign studies as well as collecting work done in Argentina.[5] The Fundación also published a directory of Argentine researchers involved in fisheries and freshwater aquaculture.[6]

Only limited research on the principal Argentine shrimp species has been conducted in Argentina. Foreign specialists and research groups have shown little or no interest in working with Argentine indigenous species. Various Argentine research groups, however, have conducted some studies on shrimp culture.

IBM: The Instituto Biologia Marina (IBM) at Mar del Plata did some research on two indigenous species (*P. muelleri* and *A. longinaris*) during the 1970s and 1980s.[7] Researchers concluded that it was technically possible to culture the two species, but climatic conditions did not permit low-cost extensive growout operations.

INIDEP: The Instituto Nacional de Investigacion y Desarrollo Pesquero (INIDEP), is Argentina's principal fisheries research institute. INIDEP, in response to industry interest, has conducted some hatchery research at its Nagera Aquaculture Center. The center is located at Barranca de los Lobos, in the Mar del Plata area of Buenos Aires Province (figure 1). Ecuadorean specialists have reportedly been engaged to assist with the shrimp culture work.[8] The INIDEP research team has focused primarily on *P. muelleri*.[9] More limited work has also been done on *A. longinaris* and *Penaeus stylirostris*. The biology of *P. muelleri* had previously been studied in detail and INIDEP is now seeking to assess its potential for culture. INIDEP has conducted trial growout runs of individuals collected in the wild at a private facility, Tres Bonetes. Few details are available to the authors on these trials.[10] INIDEP has also done some hatchery work. It first reported production of pl from berried females collected in the wild during 1990.[11] One observer reports that 300 specimens taken during an INIDEP stock assessment study in the Gulf of San Jorge were used for aquaculture research.[12] Reports in mid-1991 indicate INIDEP was preparing to



conduct further studies on 450 additional individuals collected in the Gulf of San Jorge (figure 1).[13] A cost-benefit study was completed for a 10-ha farm which estimated production costs at under $2 per kilogram.[14] The INIDEP work has addressed eyestalk ablation, moulting, diet, environmental impact on survival,

growth rates, and other subjects.

SNCT: The Secretaria Nacional de Ciencia y Technologia (SNCT) is funding a small project on *P. muelleri* physiology and nutrition as part of the Biotechnology Program (CABIO). Both INIDEP and Brazilian researchers are participating in the project.[15]

IV. INDUSTRY

Commercial groups have also expressed an interest in both marine and freshwater shrimp culture.

A. Marine species

One company, **Aquatrading**, was primarily established to promote shrimp farms, but no details are available on its accomplishments or current status.[16] One private group is reportedly experimenting with shrimp culture in Buenos Aires Province, Argentina's most northerly coastal province (figure 1). **Langostinos Patagonicos** (LP) has built a hatchery and growout ponds at Tres Bonetes in the Mar del Plata area near Stroeder in Patagones District, Buenos Aires Province.[17] The company reported plans to begin trial runs in 1991.[18] Small numbers of pl are being supplied by INIDEP's Nagera Aquaculture Station.

B. Freshwater species

Other groups have expressed an interest in freshwater shrimp culture, noting the success of farmers in neighboring Brazil.[19] Small trials were conducted in 1986 and 1987 at Itati and Santo Tome in Corrientes Province and in the north of Chaco Province (figure 1)[20]. These initial groups sought to growout postlarvae (pl) imported from Brazil, but with limited technical background and inadequate facilities, results were disappointing. One group, **Acquasud**, has initiated new trials at its La Armonia farm (Riachuelo in Corrientes Province) during October 1989 with pl imported from Brazil. They reported their first successful harvest in April 1990. Yields were reportedly about 1.2-2.3 t per hectare (ha) on an annual basis.[21] The company is experimenting with various methods and believe that yields of as high as 5.0 metric tons (t) per ha are possible.[22] They reportedly constructed a hatchery in 1990 and are building 50 ha of ponds.[23] Plans call for a harvest of 30 t in 1991 and 150 t by 1992. Initial harvests are being marketed domestically, but Acqasud eventually hopes to export to Italy and Spain.[24] A private foundation, the Fundación para el Desarrollo del Nordeste (FUNDANORD), is currently seeking financing for two freshwater shrimp projects, one for a hatchery and another for a growout farm in Corrientes Province.[25]

One observer believes that based on such results, a small shrimp aquaculture industry could be developed in northern Argentina. He estimates that the industry could develop as much as 5,000 ha of ponds during the 1990s,[26] but such optimistic reports must be considered highly speculative at this point.

V. PROSPECTS

Argentina appears to have only limited prospects for developing a shrimp culture industry. Marine shrimp culture is probably limited by the temperate climate which makes it impossible to compete effectively with tropical growers. Freshwater shrimp culture is a possibility, but would probably limit growers to the domestic market. A few countries (Brazil, the Dominican Republic, Guadeloupe, and Martinique) have developed shrimp industries for their domestic market. Only one country (Brazil) is harvesting in any significant quantities and only one country (French Guiana) is currently exporting. Based upon the experiences in other Latin American countries, any rapid expansion of the industry in Argentina appears unlikely.

This report was originally prepared by Dennis Weidner and published as IFR-91/68 on August 23, 1991 and revised July 7, 1992.

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Fundación Pablo Cassará, *Directorio Argentino de Ictiología, Pesca, y Piscicultura de Aqua Dulce, 1991* (Fundación Pablo Cassará: Buenos Aires, 1991), 14 p.

Luchini, Dra. L. Aquaculture Systems, INIDEP, personal communications, March 21, 1991.

"*Macrobrachium rosenbergii*: Cultivo en agua dulce," *Redes* Vol 5, No. 52, 1990, pp. 50-51.

Mazzoni, Carlos M. Bajamar, personal communications, March 1, 1991.

Rodriguez-Marques, Gabrriel. personal communications, January 29, 1991.

Soldano, Cesar. personal communications, November 21, 1990.

Scelzo, Marcelo A. and Enrique E. Boschi, "Cultivo de Langostino *Hymenopenaeus muelleri* (Crustacea, Decapoda, Penaeidae), *Physis*, Vol. 34, No. 88, May 1975, 193-197

Schuldt, Miquel. personal communications, August 26, 1991. Dr. Schuldt has published a number of studies on grass shrimp and other crustaceans.

Vavrecka, Ivan. Fundación Pablo Cassará, personal communications, December 13, 1991.

Weidner, Dennis. "Argentine Shrimp Fishery, 1984," *International Fishery Reports*, (IFR-85/17), May 9, 1985.

_________. "Brazilian Shrimp Culture Industry," *International Fisheries Report* (IFR-90/92), December 21 1990.

U.S. Embassy, Buenos Aires, April 19, 1986.

ENDNOTES

SECTION I (Capture Fishery)

1. For details on the capture shrimp fishery see Dennis Weidner, "Argentine Shrimp Fishery, 1984," *International Fishery Reports*, (IFR-85/17), May 9, 1985.

2. Also referred to as *Hymenopenaeus muelleri* in older literature. A good review of the fishery is available in Enrique Boschi, "El Langostino de las Costas Patagonicas", *Redes* Vol. 5, No. 52, 1990, pp. 45-49.

SECTION II (Potential)

3. "Conclusiones y recomendaciones de la mesa de trabajo sobre el tema: Acuicultura," *Jornadas Internacionales de Pesca 1988/90* (Subsecretaría de Agricultura, Ganadería y Pesca: Buenos Aires, 1990), pp. 131-135.

4. Miquel Schuldt, personal communications, August 26, 1991. Dr. Schuldt has published a number of studies on grass shrimp and other crustaceans.

SECTION III (Research)

5. Ivan Vavrecka, Fundación Pablo Cassará, personal communications, December 13, 1991.

6. Fundación Pablo Cassará, *Directorio Argentino de Ictiología, Pesca, y Piscicultura de Aqua Dulce, 1991* (Fundación Pablo Cassará: Buenos Aires, 1991), 14 p.

7. Marcelo A. Scelzo and Enrique E. Boschi, "Cultivo de Langostino *Hymenopenaeus muelleri* (Crustacea, Decapoda, Penaeidae), *Physis*, Vol. 34, No. 88, May 1975, 193-197 and Boschi and Scelzo, "El Cultivo de Camarones Comerciales Peneidos en la Argentina y la Posibilidad de su Produccion en Mayor Escala" *FAO Technical Conference on Aquaculture*, (FIR:AQ/Conf/76/E.40) Kyoto, Japan, June 2, 1976. During the 1980s, INIDEP researchers (J.L. Fennucci, A. Petriella, J. Mallo, and M. Muller) have continued the research and have published a series of reports in various journals.

8. The Station is funded by INIDEP, the Buenos Aires Province Ministry of Agricultural Affairs, The Buenos Aires Province Commission of Scientific Affairs, Mar del Plata University, and the private company, Langostinos Patagonicos, S.A. Other groups participating at the Station include the Subsecretaria de Pesca (SSP) of the Ministerio de Asuntos Agrarios y Pesca and the Universidad Nacional.

9. Dra. L. Luchini, Aquaculture Systems, INIDEP, personal communications, March 21, 1991.

10. See "Marine species" below.

11. Luchini, *op. cit.*

12. Carlos M. Mazzoni, Bajamar, personal communications, March 1, 1991.

13. The broodstock was collected on a cruise conducted by the R/V *Oca Balda*.

14. Jorge L. Fenucci, Mónica I. Müler and Julio H. Magnaterra, "Factibilidad de cria de langostino (*Pleoticus muelleri*)," *Frente Maritimo*, October 1990, pp. 103-108.

15. Luchini, *op. cit.*

SECTION IV (Industry)

16. U.S. Embassy, Buenos Aires, April 19, 1986.

17. "Cria de langostinos: Proyecto para Mar del Plata," *La Capital* December 5, 1989.

18. Luchini, *op. cit.*

19. For details see Dennis Weidner, "Brazilian Shrimp Culture Industry," *International Fisheries Report* (IFR-90/92), December 21 1990.

20. Both provinces are in northern Argentina.

21. Sources vary, probably due to time differences in the reports. Acquasud officials hope to be able to increase annual yields to about 3 t per ha by 1991 or 1992.

22. Gabriel Rodriguez-Marques, personal communications, January 29, 1991.

23. One observer suggests that as many as 100 ha of ponds are planned. Rodriguez-Marques, *op. cit.*

24. "*Macrobrachium rosenbergii*: Cultivo en agua dulce," *Redes* Vol 5, No. 52, 1990, 50-51.

25. Luis Angel Arosemena, Secretaria de Ciencia y Technología, personal communications, February 21, 1991.

26. Cesar Soldano, personal communications, November 21, 1990.

APPENDICES

Appendix A.--Argentina. Addresses

Government Agencies

Direcion Nacional de Pesca Continental
Santa Fe 1548, Piso 7
Buenos Aires
ARGENTINA

Secretaria de Agricultura, Ganaderia, y Pesca
Ministerio de Economia
Av. Paseo Colon 982 -1 piso Oficina 83
1063 Buenos Aires, ARGENTINA

Companies

Acquasud, S.A.
Finca Camaronicultura La Armonia
Riachuelo, Corrientes Province
ARGENTINA

Hutfield
Sant Fé 1193, 1º piso
Buenos Aires, B.A.

Mellino Sacif
Pichincha 247
Buenos Aires, B.A.
Telephone: 47-6762

Taiyo Argentina
Belgrano 634
Buenos Aires, B.A.
ARGENTINA
Telephone: 34-1082, 34-7844

Research Institutes

Instituto Nacional de Investigacion
y Desarrollo Pesquerro (INIDEP)
Casilla de Correo 175
7600 Mar del Plata, Pcia. B.A.
ARGENTINA

Instituto de Biologia Marina (IBM)
Mar del Plata, B.A.
ARGENTINA
Secretaria Nacional de Ciencia y
Technologia (SNCT)
Address Unavailable

Appendix B.--Argentina. Shrimp catch and harvest, 1980-92

Year	Catch/harvest: Wild	Catch/harvest: Pond	Total
	Metric tons		
1980	802	-	802
1981	2,730	-	2,730
1982	7,814	-	7,814
1983	19,289	-	19,289
1984	23,118	-	23,118
1985	10,264	-	10,264
1986	6,979	Negl	6,979
1987	2,836	Negl	2,836
1988	18,090	Negl	18,090
1989	11,600	5E	11,605
1990	NA	10E	NA
1991	NA	30P	NA
1992	NA	150P*	NA

E - Estimated
P - Projected by Argentine company
* The likelihood of this substantial increase is based on Aquasud projections and has not been confirmed by any local observers.
Source: FAO Yearbook of Fishery Statistics, various years (1980-88 wild catch data); Redes 5 (52), 1990 (1989 wild catch data); various sources (pond harvest estimates)

Appendix C.--Argentina. Average temperatures near Buenos Aires, 1980-89

Month	Temperature average
	Celsius
January	24.3
February	23.1
March	20.9
April	16.4
May	13.4
June	10.2
July	9.9
August	11.6
September	13.4
October	16.6
November	19.5
December	22.6

Source: INTA-Castelar

4.2

BOLIVIA

Bolivia is a land locked country located in the center of South America. It has two distinct climatic zones, an Andean altiplano with relatively arid areas, and an extensive area in the Amazonian basin, much of which is well watered. The fishing industry is very limited, although Lake Titicaca and the Amazon tributaries offer some prospects.

Bolivia has a small aquaculture industry focusing primarily on exotic (trout) and indigenous (pejerrey) species. The only large commercial farm harvests trout. Minor projects for carp and tilapia are also underway.[1] Few Bolivians have formal aquaculture training and the industry's infrastructure is poorly developed. Despite the limited development, the country has enormous potential to develop an aquaculture industry. One report estimates that Bolivia has 1 million hectares of freshwater surface area.[2]

No Bolivian groups are currently culturing shrimp. Being a land-locked country, growers are restricted to freshwater species. Some observers believe, however, that freshwater shrimp could be cultured in the tropical conditions of the country's Amazonian Basin.[3] At least one company, **Rivera & Asociados**, is known to have expressed an interest in culturing shrimp.[4] The Bolivian Centro de Desarrollo Pesquero is currently conducting a feasibility study on small-scale shrimp culture. If such projects are found to be viable, a pilot project will be implemented in 1993 to produce freshwater shrimp (*Macrobrachium rosenbergii*) for domestic consumption.[5] One U.S. researcher believes that the environmental conditions in the Amazonian Basin are also well-suited to culture Louisiana crawfish. New Bolivian regulations, however, concerning the importation of exotic species would preclude such an effort.[6] As a result of this restriction and the limited aquaculture infrastructure, it is unlikely that a shrimp culture industry will develop during the 1990s.

This report was originally prepared by Dennis Weidner as IFR-92/16 on February 21, 1991 and slightly revised on July 21, 1992.

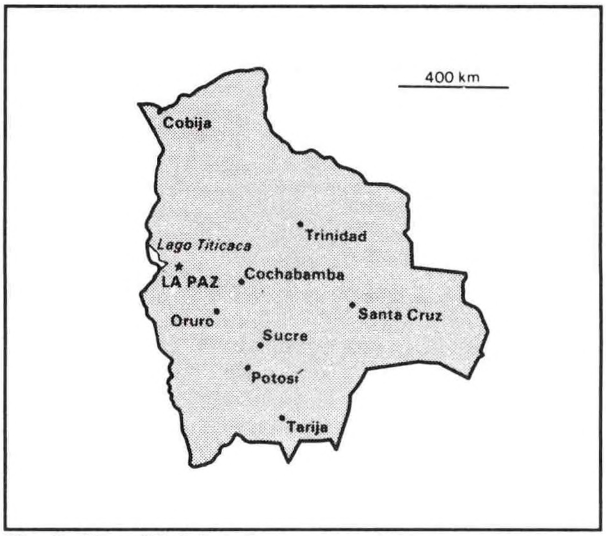
SOURCES

Centro de Desarrollo Pesquero, *Estadistica e Informacion Pesquera de Bolivia*, 1980-89, CDP: La Paz, April 1990, 43 p.

Elsy, Richard. Trinidad Project Manager, British Fisheries Mission, personal communications, April 9, 1991.

FAO. "Report of the Fifth Session of the Working Party on Fisheries Resources of the Commission for Inland Fisheries of Latin America," *FAO Fisheries Report*, No 442, Santiago, Chile, September 24-28, 1990.

Harvey, J.M. U.K. Fisheries Adviser, personal communications, June 17, 1991.



Map 1.--Map of Bolivia.

Rivera Rodas, Edgar J. personal communications, February 25, 1987.
U.S. Embassy, La Paz, July 17, 1992.

ENDNOTES

1. A good description of Bolivia's fishing industry, including aquaculture, is available in Centro de Desarrollo Pesquero, *Estadistica e Informacion Pesquera de Bolivia*, 1980-89, CDP: La Paz, April 1990, 43 p.

2. FAO, "Report of the Fifth Session of the Working Party on Fisheries Resources of the Commission for Inland Fisheries of Latin America," *FAO Fisheries Report*, No. 442, Santiago, Chile, September 24-28, 1990. p.4.

3. Richard Elsy reports that he generally concurs with this appraisal based on his experience in Indonesia, but can not make a firm assessment as he has only recently arrived in Bolivia. Richard Elsy, Trinidad Project Manager, British Fisheries Mission, personal communications, April 9, 1991.

4. Lic. Edgar J. Rivera Rodas, personal communications, February 25, 1987.

5. U.S. Embassy, La Paz, July 17, 1992.

6. J.M. Harvey, U.K. Fisheries Adviser, personal communications, June 17, 1991.

APPENDICES

Appendix A.--Bolivia. Addresses

Government Agency

Centro de Desarrollo Pesqueria
Min. de Asuntos Campesinos y Agropecuarios (MACA)
Casilla 1728
La Paz, BOLIVIA

4.3

BRAZIL

Brazil may have significant potential to culture shrimp, although experts differ considerably on the industry's prospects. Brazil's 8,000 kilometer coastline and substantial wild shrimp resource suggest the possibility of a viable shrimp culture industry. Observers point out that Brazil has many other important requirements, such as large expanses of low-cost and uninhabited coastal **land**, tropical **climate**, several indigenous **species** of *Penaeid* shrimp, inexpensive **labor**, and an extensive **agro-industrial base**. Some believe that Brazil may actually have more potential shrimp culture sites than all the other South American countries combined. Given the country's attributes, Brazilian growers should be able to develop one of the region's most important shrimp culture industries. Brazil's extensive coastline alone, about half of South America's tropical coastline, suggests that the region's shrimp culture potential will largely be determined by the results Brazilian farmers achieve.

Other observers are cautious and suggest that the marginal results achieved after a decade of considerable private effort and some Government support may indicate that many projections are wildly optimistic. Skeptics point to several factors which have slowed the industry's development. Some experts maintain that a variety of **hydrological problems** make large areas of the coast unusable for shrimp culture. Inappropriate **soil characteristics** make other areas unsuitable. Inadequate **infrastructure**, such as roads and utilities, make it difficult to develop many potential sites. Brazil also has only limited capabilities to produce fishmeal, an important ingredient in **shrimp feeds**. Some of the problems experienced by the industry, however, seem not to be related to the country's underlying physical and climatic characteristics, but rather to inappropriate policies pursued by Government officials and errors made by the early growers. One of the most serious obstacles to the industry's development has been **Government policy**, which financed many poorly designed farms and which effectively excluded foreign participation, isolating Brazilian growers from needed investment capital and rapidly improving technical innovations. Early growers also appear to have pursued **investment strategies** inconsistent with proper farm management. Many growers launched projects without adequate **technical expertise** and as a result made serious errors in site selection, farm design, and growout strategy. Another serious obstacle to the development of the Brazilian shrimp culture industry has been the initial focus on an **exotic species** which proved to be an unfortunate choice. The attention to exotics delayed needed research on the culture potential of indigenous species. Early farmers reported disappointing results with indigenous species and many concluded that they were not suitable for pond culture. This and other technical and managerial problems resulted in numerous closings of pond projects in the mid-1980s, leading some to question the industry's potential in Brazil.

There is now growing, but not unbridled, optimism in Brazil about the industry's future. Many observers believe that the initially disappointing results were not due to any underlying physical or climatic factors. An increasing number of investors have concluded that Brazilian conditions are favorable for culturing shrimp and that the industry will emerge as one of the largest in Latin America. Farmers are reportedly achieving improved results, both with indigenous and exotic species. Some Brazilian observers are convinced that the industry has finally turned the corner and a period of substantial expansion is about to occur. Limited data on Brazilian operations, however, do not yet permit any firm conclusion over the industry's future. Scattered reports of farm closings and technical problems at various farms continue. Profitable commercial-scale operations, even by the most optimistic assessments, have been achieved at only a small number of farms.

Brazilian harvests of marine and freshwater shrimp are still very limited. While precise data are not available, the consensus in the industry is that farmers only harvested about 2,000 metric tons in 1989 and will probably not exceed 2,500 tons in 1990. Some local observers believe even these relatively modest estimates to be unrealistically high. Shrimp culture analysts have previously made widely optimistic reports concerning developments in Brazil and other Latin American countries, which did not materialize. Most observers believe that farmers should be able to substantially increase harvests during the 1990s. The significant problems faced by farmers, however, will probably limit the ability of the industry to rapidly expand. The many unanswered questions about the industry's future make projections highly speculative at this time, but harvests of 10,000 tons by 2000 seem a reasonably conservative assessment of current trends. It should be stressed, however, that some local observers would view such a projection as overly optimistic, while others will view it as unduly pessimistic.

Several macro-economic factors further complicate the Brazilian situation. The Brazilian economy faces enormous debt, inflation, and unemployment problems. President Collor's drastic economic program addresses these problems, but the long term impact of the program is yet to be determined. The tight fiscal situation created by the President's program is having a particularly adverse impact on newly developing industries, such as shrimp culture, which require significant inputs of new investment capital. Other factors such as interest rates, exchange rates, fuel prices, and economic trends in countries which import shrimp will also have major impacts on the industry's development.

CONTENTS

I. CAPTURE FISHERY

Brazil conducts one of the two major capture shrimp fisheries in Latin America.[1] The catch is primarily various species of **marine** shrimp. Brazilian fishermen operate about 500 trawlers according to unconfirmed 1990 estimates[2], as well as a variety of artisanal vessels and gear. Shrimp is fished all along the Brazilian coast, but the larger quantities are taken in the more developed southern fishery. Marine shrimp catches since 1980 have ranged from a high of 67,500 metric tons (t) in 1985 to a low of 46,300 t in 1981 (appendix C1 and figure 1). Since 1986, catches have stabilized at 54,600-57,800 t, but preliminary reports suggest that the 1989 catch was "a disaster."[3] Brazil also reports a substantial catch of **freshwater** species, unlike other Latin American countries which report only small catches. Brazilian fishermen during the 1980s reported freshwater shrimp catches usually exceeding 10,000 t annually (appendix C1 and figure 1).

Map 1.--Map of Brazil.

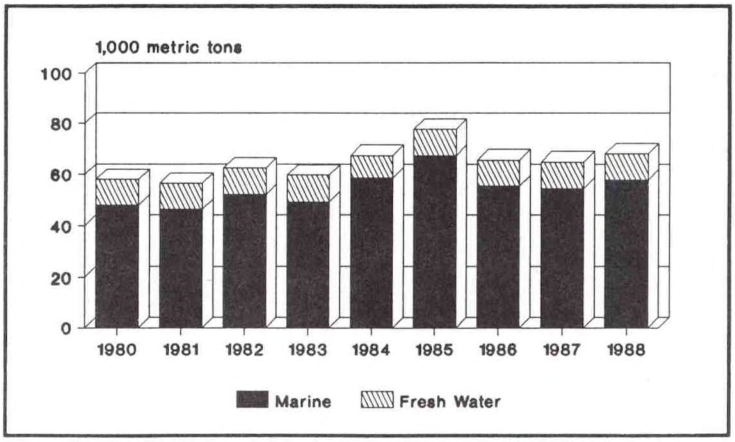


Figure 1.-- Brazil. Marine and freshwater shrimp catch, 1980-88.

Northern fishery: The northern fishery is conducted primarily from the states of Maranhão and Para (appendix C2). Almost 25 percent of Brazil's shrimp catch was taken in the northern fishery during 1987 (figure 2), the latest year for which detailed catch data is available. Most of the marine catch is various species of *Penaeid* shrimp. A small catch of seabobs was reported in Maranhão.[4] Shrimp dominates the fishing industry in these lightly populated northern states. Most of the country's sizeable shrimp exports are taken in the northern fishery. Two species taken in the northern fishery (*P. schmitti* and *P. subtilis*) are the indigenous species which are proving the most suitable for pond culture. (See "Species".) Fishermen in Para also report a substantial catch of freshwater shrimp, about 40 percent of Brazil's overall catch of freshwater species. Almost all of the freshwater shrimp catch is consumed domestically.

Northeastern fishery: The northeastern fishery is conducted primarily from the states of Bahia and Ceara. The shrimp fishery is less dominate in the northeast than the north. Other fisheries such as that for lobster rival it in importance. The combined shrimp catch for the northeastern states, however, almost equals the northern catch (figure 2). Most of the catch is *Penaeid* shrimp, but some seabobs and freshwater species are taken, mostly in Alagoas and Ceara, respectively (appendix C2).

Southern fishery: The southern states dominate the Brazilian shrimp fishery (figure 2). Almost all of the catch is marine shrimp, both *Penaeids* and lower-value species such as seabobs. Several states report important fisheries, São Paulo, Rio de Janeiro, Santa Catarina, and Rio Grande do Sul (appendix C2).[5] The southern fishery accounts for about half of the country's overall shrimp catch. A few growers have expressed an interest in a pink shrimp (*P. paulensis*) taken in the southern fishery, but slower growth rates may make it difficult to compete with competitors using tropical species.[6]

II. CONDITIONS

A. Environmental

Brazil's 8,000 kilometer (km) coastline and large wild shrimp resource suggest that a viable shrimp culture industry is possible. Brazil has many important industry requirements.

Land: There are large expanses of low-cost coastal land with tropical forestry. Large stretches of the Brazilian coast are only lightly populated and not yet developed. Such land is still available at very low prices.

Species: Some indigenous warm-water *Penaeid* species appear to have considerable potential for pond culture. While early farmers generally dismissed indigenous species, the industry is increasingly concluding that some can be successfully cultured.

Climate: Brazil's tropical climate is ideal for culturing tropical *Penaeid* shrimp. Unlike the situation along the Pacific coast of South America[7], large stretches of the Brazilian coast (north of Cabo Frio) have seasonably stable, warm water temperatures (figure 3) --an important factor in achieving fast growth rates.[8] Except in the southern-most states there is no temperature problem to overcome (appendix D1-2). The warm temperature

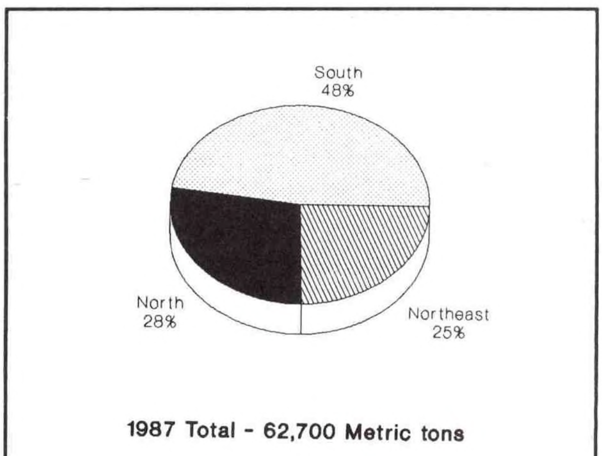


Figure 2.--Brazil. Shrimp catch by region, 1987.

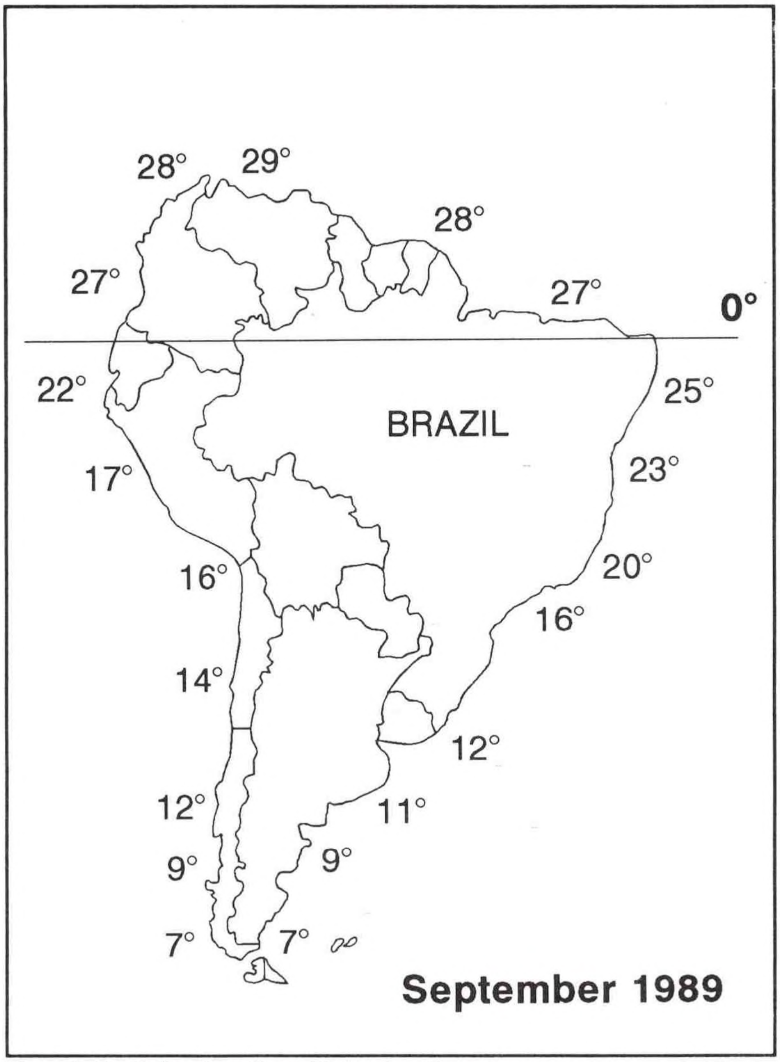


Figure 3.--South American Coastal Seasurface Temperatures.

prevalent along most of the coast may require farmers to increase exchange rates somewhat and to allow pond water levels to rise slightly to alleviate high afternoon temperatures.

Many important factors have not been adequately researched, making it difficult to fully assess the Brazilian potential to culture shrimp.

Hydrological conditions: The overall impact of hydrological conditions is not clear. While Brazil has one of the world's most important freshwater resources, large areas of Brazil are quite arid. Freshwater is scarce along much of the northeastern coast where many otherwise ideal sites can be found. Inadequate freshwater makes it difficult to adjust salinities. The reverse problem may be true for sites near the Amazon River. The Amazon transports such a large volume of freshwater that even farmers located at some distance from the river might have difficulty obtaining seawater to maintain salinities.

Seasonal changes: One factor which some Brazilian farmers are finding it difficult to contend with are extremes in salinity as a result of significant seasonal changes.[9] In much of the Northeast the rainy season begins in January and lasts until April/June. Salinity can vary 0 to 55 parts per thousand (ppt). The salinity range at farms can vary widely, even at farms located close to each other, depending on a wide range of factors. Considerable differences also exist between states. In Rio Grande do Norte, the rainy season begins in April and ends in July and salinities vary from 5 to 29-49 ppt. In Bahia, it rains through much of the year and there is little change in salinity. In the south the seasons follow a more temperate summer/winter pattern. Salinities in Santa Catarina vary from 5 to 30 ppt.

Soil characteristics: Another still largely undetermined factor is soil characteristics, such as pH levels and soil types. Both factors are extremely important in determining where farms can be built. One observer suggests that the sandy soils prevalent at many potentially suitable sites has raised Brazilian construction costs.[10]

B. Economic/Political

Brazil offers several economic advantages to shrimp farmers. There is a large pool of inexpensive **labor**. Brazil has a rapidly growing population and job opportunities in the rural areas near shrimp farms are often very limited. A substantial **agro-industrial base** exists to supply Brazil's agricultural and livestock sector. While the country's aquaculture industry is still a rather minor activity, many of the products and services needed by shrimp and fish farmers can be efficiently provided by companies already supplying similar products to farmers and ranchers throughout the country. Brazil also provides a significant **domestic market** for shrimp. Unlike other Latin American countries which primarily export shrimp, there is a strong domestic market in Brazil, simplifying distribution and marketing efforts. (See "Marketing.")

Farmers have experienced a variety of economic and political problems in Brazil and many of these problems have not yet been resolved. One particularly serious problem impeding the industry's development has been the **limited foreign participation**. Brazilian investment laws and foreign currency regulations have generally discouraged foreign groups. This has restricted needed infusions of investment funds, a particularly serious problem in Brazil after the 1982 debt crisis severely constricted domestic credit markets. Scattered reports of failing shrimp farms probably discouraged many potential investors from entering the industry. The limited foreign participation also reduced Brazilian contacts with other farmers and research groups, thus restricting access to the rapidly improving technology developing in other countries. **Inappropriate methods** caused difficulties for many farmers. Currently farmers are shifting from extensive to semi-intensive methods,[11] but using such methods at farms with large ponds built for extensive operations poses difficulties. Converting the large ponds used in extensive systems to semi-intensive operations will in many instances prove very costly. **Import restrictions** create many problems by complicating the purchase of equipment and supplies that farmers need. Importing needed equipment and supplies often proves to be a complicated and expensive undertaking, even though domestic suppliers are unavailable. Farmers have reported a variety of other problems. The necessary **infrastructure**, including roads, electricity, etc., is lacking in many coastal areas. The often great distances from important urban centers is a major factor in the limited infrastructure and on the construction costs, which tend to be very high. Farmers report pond **construction costs** of up to $20,000 per hectare (ha), far above production costs in Ecuador and most other Latin American countries.[12] **Energy costs**, both oil and electricity, tend to be very expensive. Brazil is highly dependent on imported oil and increases in oil prices could have extremely negative consequences on farmers. **Financing** is difficult to obtain and relatively expensive. Brazil's overall economic situation has restricted credit markets and investors are especially wary of new industries without proven track records. **Feed** has been a special problem for farmers. The small size of the industry has not attracted the serious attention of Brazilian feed companies, although the first prepared feed was introduced in 1984. A great deal of research needs to be conducted to formulate feeds suitable for indigenous species and farmers will likely continue to have difficulty increasing yields until such improved feeds are developed. Producing adequate quantities of feed may be a problem as domestic fishmeal production may also prove inadequate. (See "Feeds.") **Technical expertise** is still lacking in the industry. Few Brazilians have academic degrees specializing in shrimp aquaculture or the technical skills needed for the increasingly sophisticated semi-intensive farms. This is changing as Brazilian universities are offering more sophisticated aquaculture programs, many with postgraduate aquaculture degrees and even some specialized shrimp culture programs.[13] Brazil's vast **size** creates another problem. The industry is currently so widely dispersed throughout the country (appendices G1-10) that farmers can not yet command the economies of scale needed to create an efficient service industry.

C. Overview

The failure of so many of the early farms created the impression, both within Brazil and among foreign observers, that the country may not be able to support a successful shrimp culture industry. One Government official estimates that farms with a total of about 900 ha of ponds have been closed, but believes that the projects now operating are "reaching a stable stage" which will serve as a sound foundation for future expansion.[14] Many Brazilians insist that the country will support a viable shrimp culture industry. They are convinced that the early difficulties resulted primarily from misguided Government policies.[15] Others are convinced that the difficulties obtaining acceptable yields from indigenous species has been a major obstacle.[16] Some observers are becoming more optimistic that Brazilian shrimp farmers, with their increasing experience, improved methods, and better pond designs, are finally beginning to report the commercial success that has so far eluded the industry. Several observers reported increased harvests in 1988 and 1989 and another increase is projected for 1990 (appendix E2). One observer insists that an increasing number of farms are achieving commercial success.[17] These optimistic reports, however, are not unanimous. Some observers are highly skeptical of available harvest data. Others point out that only a relatively small number of farms have achieved commercial success and that scattered reports of farm failures continue to plague the industry.

III. POTENTIAL AREA

Brazil's huge coast have prompted some to conclude that the country will support a massive shrimp culture industry. The country has half of South America's tropical coastline. That huge expanse of coast, however, does not necessarily mean that large areas are suitable for shrimp culture. The key question is how much of the coast has the right mix of conditions that would permit successful culture operations. (See "Conditions.") Estimates of the potential area suitable for shrimp culture vary widely. The greatest potential area for marine species appears to be in northern and northeastern Brazil. Some estimates are as high as 800,000 hectares. The State of **Bahia** estimated that 200,000 ha of shrimp ponds could be built in that State alone.[18] Another study estimated that there may be up to 100,000 ha of sites in the state of **Rio Grande do Norte**. There is also some, although more limited, potential for other species and other areas. One observer believes that about 3,000 ha in **Espirito Santo** and **Rio de Janeiro** are suitable for freshwater culture. Perhaps 5,000 ha in **Santa Catarina** could be used for culturing marine species tolerant to cold weather, although the economics of such operations are still speculative.[19] These optimistic estimates should be viewed with considerable caution. Many were made without rigorous surveys or the participation of experienced shrimp culture specialists.

While some of these estimates may be wildly optimistic, even conservative estimates suggest that there are very large areas in Brazil which could be devoted to shrimp culture. The most thorough survey conducted to date has been a 1989 Brazilian Federal Government project using satellite imagery to map potential sites. As a result of the survey, the Government designated 111,000 ha along Brazil's northeastern coast as "priority" areas for establishing shrimp farms.[20] Subsequent surveys on the ground, however, might find that many areas identified by satellite are not appropriate for development, or conversely identify additional areas for development.

Marine shrimp: The Government targeted 82,000 ha for development as marine shrimp farms (appendix E1). The Government currently estimates that Maranhão, and to a lesser extent Bahia and Rio Grande do Norte, may prove to be the states with the greatest potential for marine shrimp culture. Details on the area in each state most suited for culture are available in the Inter-Ministerial report. The Government's 82,000 ha target for marine ponds is what they seek to develop in the next few years. The area of mangrove estuaries in Maranhão (516,000 ha) and Para (215,000 ha) suggest that there is a huge area available for future development (appendix E1).[21] While the Government's 5-year development plan is probably over optimistic in what can be accomplished by 1995, the area of suitable sites could be much larger than the 82,000 ha initially identified for development.

Freshwater shrimp: The Government targeted 29,000 ha in the São Francisco and Jaguaribe river valleys for freshwater shrimp farms.[22] The Brazilian potential for freshwater shrimp culture would appear particularly large given the significant freshwater resource available in many areas of the country.

The potential area suitable for shrimp culture is not an absolute number, but is dependent on many factors beyond actual climatic and physical factors such as soil and water conditions. A variety of technical and economic variables will also affect the area which can be used for culture. If Brazilian conditions prove favorable for culturing shrimp and farmers develop effective methods for indigenous species, they may be able to use not only the sites with ideal conditions, but also more marginal areas. This would significantly increase the potential area available. Future trends in shrimp prices will also affect the extent to which such marginal sites can be developed. Higher prices would make farms with lower yields economically feasible.

IV. SPECIES

A. Marine Species

Brazilian marine shrimp farmers use a wide variety of indigenous and exotic species. Some biologists initially believed that imported *P. japonicus* would be the best species to culture because of encouraging early trial runs. Brazilian farmers which focused on *P. japonicus*, however, reported generally disappointing yields in commercial operations. Most have switched to other species, both indigenous and exotic.[23] Several growers began using *P. vannamei* in the mid 1980s, some with considerable success. Currently an increasing number of growers are turning to indigenous species, especially *P. schmitti* and *P. subtilis*. There is a very obvious advantage to using indigenous species in that they are available locally. Not only can postlarvae (pl) be collected[24] for immediate stocking, but so too can wild adults for broodstock and already mated females with fully developed ovaries from which viable spawnings can be conducted.

Indigenous Species: Growers have experimented with indigenous species, but very little published research is available concerning the results achieved using these species (*P. brasiliensis, P. paulensis, P. schmitti*, and *P. subtilis*). The earliest growers considered most indigenous species too risky for their early operations.[25] Much of the work by growers has been informal trials and not carefully documented scientific studies. The development of culture methods for indigenous species is critical for the future of Brazil's shrimp culture industry. The use of exotic species[26] requires greater technical sophistication than is currently available in Brazil because of the need for hatcheries. This substantially increases capital expenditures because of the need to build hatcheries.[27] Many observers believe that the key to using indigenous species is the development of appropriate feed and feeding strategies. As a result researchers are giving considerable attention to nutrition.[28] Successful farms in developing countries like Brazil generally are built with limited funds using basic, low cost technology. Such an approach would take maximum advantage of Brazilian conditions where manual labor costs[29] are low and capital costs high. If farmers have to use exotic species this considerably increases the investment required as well as the technical sophistication needed. Using exotics requires, for example, the construction of a hatchery or the purchase of expensive hatchery pl rather than purchasing the pl from low-paid workers and artisanal fishermen who can collect indigenous species in local estuaries. The expense and difficulty involved in building and staffing the more technically sophisticated operations significantly restrict the number of individuals who can enter the industry, as well as raising production costs. Growers are currently turning to two indigenous species (*P. schmitti* and *P. subtilis*), but others are still committed to exotics (especially *P. vannamei*).[30]

P. schmitti: This species of white shrimp occurs off northern and northeastern Brazil as far south as Cabo de Santa Marta Grande in Santa Catarina state. It has many characteristics similar to *P. vannamei*. It is a very active, voracious feeder which probably necessitates high caloric intakes. Its protein and energy requirements, as a result, probably exceed that of *P. vannamei*.[31] Brazilian researchers are just beginning to assess this species aquaculture potential. Important maturation work is under way at the Universidad Ferderal de Santa Catarina.[32] The University's hatchery (Laboratoio de Peneſdeos de Barra da Lagos) produces for farms in southern Brazil (appendix G8) which grow *P. paulensis* during the winter and *P. schmitti* during the summer. Much of the early research on *P. schmitti* and *P. subtilis* was conducted by Maricultura da Bahia (MB) which, however, eventually decided to focus on exotic species. MB researchers believe that *P. schmitti* surpasses *P. vannamei* in reproductive performance (maturation rate and nauplii production), survival, and pl production.[33] MB researchers reported lower growth rates, about 14 gm after 120 days compared to 16-18 gm for *P. vannamei*. MB researchers concluded that *P. schmitti* was not as robust as *P. vannamei*.[34] The Brazilian Environmental Institute (IBAMA) reports that *P. schmitti* reaches 25 grams (gm) in 120 days in extensive ponds. IBAMA also reports, however, that results at semi-intensive farms are generally "poor," probably due to inappropriate feed.[35] One former MB researcher insists that it is more accurate to refer to *P. schmitti* yields as "fair" rather than "poor." He concurs with IBAMA, however, that yields do decline in semi-intensive systems, probably because of a dietary deficiency.[36] SOCIL, a French company operating in Brazil, also reports that *P. schmitti* performs well in extensive ponds. Coelho reports that extensive farmers can harvest 12-20 grams (gm) shrimp in about 4-5 months.[37] Growth in semi-intensive ponds, however, stops at about 10-12 gm after 100-110 days.[38] One observer reports that the first significant trial runs were not conducted until 1988.[39] As a result, Brazilian farmers are still at an early stage in efforts to utilize this species. Farmers in several Caribbean countries have also shown an interest in *P. schmitti* and Cuba, Venezuela, and other countries are reportedly conducting considerable research on this species.

P. subtilis: This brown shrimp occurs along the northern and northeastern coast, as far south as Cabo Frio in Rio de Janeiro state.[40] It is becoming increasingly popular among Brazilian growers, although most have only recently turned to it. Like *P. schmitti*, growers have only recently commenced significant trial runs. One advantage to using this species is that it is reportedly easier to produce pl than with other marine species. Many growers have reported success in producing pl from broodstock. Growth rates, however, are less than those achieved with *P. schmitti*. Growers report that it takes 4-5 months to produce 12-14 gm shrimp. Little research has been done, however, on nutritional needs or appropriate culture methods.

Photo 1.--Brazil. Shrimp harvested from the Maricultura de Bahia farm at Valença. © Nilton de Souza, Mariculture de Bahia

P. brasiliensis: This pink shrimp occurs as far north as the southern U.S. coast, although in relatively limited quantities. It is much more important in the commercial fishery from Guyana south to Brazil. It occurs all along the Brazilian coast, but the southernmost range ends in the area of the Santa Catarina-Rio Grande do Sul border. It is not widely used by growers. Trial runs have yielded generally poor results. It is occasionally used if growers cannot obtain pl of preferred species. The species is also often present (quantities vary) in deliveries of wild pl collected in estuaries. While farmers have not had encouraging results with this species, some observers believe that more emphasis should be given to research on it.[41] Pink shrimp is particularly prized on the Brazilian market and there would be a ready market for cultured harvests.

P. paulensis: This pink shrimp has the most southerly range of the important Brazilian shrimp species. It occurs from Cabo Frio south to Mar del Plata in Argentina. The Rio Grande University (Rio Grande do Sul) and the Federal University of Santa Catarina have conducted some research on the species. The Rio Grande University has also initiated a restocking program in Patos Lagoon where artisanal fishermen have reported sharp variations in their annual catches.[42] Considerable interest has been focused on this species as investors in southern Brazil are interested in identifying a species suited for culture in the more temperate climate of southern Brazil. Several small farms are currently using the species and there are plans for the construction of larger farms. *P. paulensis* reportedly maintains acceptable growth rates, better than other indigenous species, in colder water and pl are available in estuaries. Attempts to use this species at warmer northern sites have yielded poor results.[43] Hatcheries have had difficulty, however, producing healthy postlarvae. Farmers report that the survival rate of hatchery pl is extremely low, only about 30-40 percent. Researchers at the Federal University of Santa Catarina (UFSC) and the Fundaçao Universidade do Rio Grande are working on this problem. Important hatchery work has been conducted at the UFSC's Laboratorio de Peneídeos de Barra da Lagoa. Researchers have reported poor results in semi-intensive ponds. The reason for the poor yields is unknown, but is probably the lack of an appropriate feed.[44]

The authors have received conflicting reports concerning the indigenous species favored by Brazilian growers. The U.S. Embassy in Brasilia and a local observer reported in 1985 that *P. schmitti* was the preferred indigenous species, although *P. subtilis* was probably more commonly used because of the availability of postlarvae. Another report suggests that *P. schmitti*, *P. subtilis*, and *P. brasiliensis* have proven acceptable to the farmers.[45] Most reports suggest, however, that farmers have had disappointing results with *P. brasiliensis*. Recent data furnished the author by the Brazilian Government indicates that *P. schmitti* is the most widely used indigenous species with nearly 90 percent of the farms devoting at least part of their operations to the species. The Government also reported, however, that *P. subtilis* is harvested in greater quantities (appendix F2).[46] While precise data on the species used is not available, it does appear that Brazilian growers are having increasing success with indigenous species, especially *P. schmitti* and *P. subtilis*. If so, Brazil could emerge as the first Latin American country to base an important shrimp culture industry on Atlantic-coast species.

Exotic Species: Brazilian growers have experimented with several exotic species. The earliest projects used *P. japonicus*.[47] The most important marine exotic species currently being used in Brazil is *P. vannamei*, as in other Latin American countries. Growers also use *P. penicillatus*, but harvests are more limited than with *P. vannamei* (appendix F2). Growers have also experimented with *P. stylirostris*, *P. monodon*, and *P. aztecus* but with less success. Current work with *P. stylirostris* and *P. monodon* is believed to be negligible. Two small farms report working with *P. aztecus* (appendix G5), but they are probably inaccurately identifying the species. Local hatcheries have attempted to produce pl for all these species in the past, but *P. vannamei* and *P. penicillatus* are the only imported species currently available locally. Most growers have turned increasingly to indigenous species, especially as improved methods and formulated feeds are now resulting in higher yields. As a result, the use of exotic species may decline in the future. Currently only four growers are reportedly using exotics. As two of them are the large PESCON[48] and Maricultura da Bahia farms (appendix G5),[49] the overall harvest of exotics is still an important part of Brazil's harvest (appendix F2).

***P. vannamei*:** This species of white shrimp occurs along the Pacific coast of Latin America from northern Peru north to the United States. It has served as the basic species used by the highly successful Pacific-coast shrimp farmers. Farmers report that it performs well in extensive and primitive semi-intensive systems and does well even with the relatively low-protein feeds often available in Latin America. The species has also reportedly been used by several Brazilian farmers and is currently the exotic species most widely used in Brazil. Only about 17 percent of Brazilian farms, however, currently work with the species, but as some of the ones that do are the larger farms, it constitutes an important portion of the overall cultured harvest (appendix F2). Growers reportedly began experimenting with *P. vannamei* after pl became available from the MB hatchery. Brazilian growers have expressed considerable interest in the species, noting the extensive use in Ecuador and other countries, rapid growth rates, existence of hatchery technology, extensive research on growout methods, and the acceptance on the U.S. market. The lack of any system of inspection and certification, however, has apparently resulted in the transportation of various pathogens throughout the growing area. MB reportedly faces serious disease problems because of imported postlarvae.[50] One industry source reported in 1988 that many farms were abandoning *P. vannamei* and other exotic species in favor of indigenous species.[51] The situation is somewhat confusing, however, as other observers indicate increased demand for *P. vannamei* seedstock in 1989 and 1990.[52]

***P. japonicus*:** This Asian species, generally referred to as Kuruma shrimp, occurs in the wider Indo-Pacific from the Red Sea east to Japan and Korea. In recent years it has moved through the Suez Canal and has been reported off southern Turkey. The species was used by several early Brazilian growers, primarily because of encouraging results in trial runs. The species had been extensively studied by other countries and a considerable body of research existed on both hatchery and growout technology. The Superintendencia de Desenvolvimiento de Pesca

Photo 2.--Brazil. Some Braziian observers are particularly enthusiastic about the potential for culturing Macrobrachium rosenbergii. Dennis Weidner

(SUDEPE) actively promoted its use as part of its shrimp culture development efforts.[53] Some of the early Brazilian operations were described by Cornelius Mock.[54] Climatic changes and industry experience, however, have caused growers to shift operations to other species. (See "Marine Species.") The species limited tolerance to salinity change may partially explain problems experienced by Brazilian growers.

P. penicillatus: This species, often referred to as red-tailed shrimp, occurs extensively in the Indo-Pacific, from Pakistan east to Indonesia and Taiwan. It has been used by Chinese and other Asian shrimp farmers. A few Brazilian growers, mostly in Bahia, are using the species and it constitutes an important portion of the cultured harvest (appendix F2).

P. aztecus: This species of brown shrimp is commercially important in the U.S. shrimp fishery, both along the U.S. Atlantic coast and in the Gulf of Mexico. Several U.S. groups have attempted to assess the potential for pond culture. The species is similar to *P. subtilis*, which until 1976 was generally considered a subspecies. Many of the references to its use in Brazil probably result from erroneous identification and may refer to *P. subtilis*.

P. monodon: Black tiger shrimp is widely used in Asian aquaculture industries. *P. monodon* is an euryhaline species with a wide tolerance for salinity changes, but the optimal growth rates are reported in water of from 5 to 25 ppt and would thus be affected by the harsher conditions prevalent at many Brazilian farms. A few Brazilian growers, including MB, have conducted trial runs.

B. Freshwater Species

Brazil conducts Latin America's largest fishery for river prawns (*Macrobrachium sp.*)[55]. Catches varied from 8,800-10,500 t during the 1980s (appendix C1 and figure 1), almost all of which was taken by artisanal fishermen. Growers are also trying to culture freshwater shrimp and some reports suggest this is the fastest growing sector of the industry. Freshwater culture is currently limited more by marketing difficulties than the ability of the farmers to increase harvests.[56] Indigenous species have not proven suitable for pond culture and almost all cultured operations are believed to utilize *M. rosenbergii*. Most freshwater shrimp operations are relatively small, but an increasing number of Brazilians are working with the species and cultured harvests are growing. The Brazilian freshwater shrimp culture industry consists of about 100 semi-intensive farms with about 300-400 ha of ponds (appendix G1). Estimates vary, but freshwater cultured harvests in 1989 probably totaled about 700 tons.[57] The potential is probably greatest in the São Francisco[58] and Jaguaribe River valleys. Most of the ponds in northeastern Brazil are located in the central São Francisco River valley, Juazeiro (Bahia), and Petrolina (Pernambuco).[59] Some ponds are also located in Alagoas, near Coruripe. A substantial number of ponds are located in southern Brazil, primarily Rio de Janeiro and Espirito Santo (appendix G1). Fewer farms are located in the southern-most states. Rio Grande do Sul, for example, had only about 8 ha of ponds in 1990, divided among 23 farms.[60]

Most farms are small (0.5-10.0 ha), family-run operations using semi-intensive methods, but some larger companies with foreign backing are now entering the industry.[61] The farms are most commonly located in irrigation projects and on small agricultural properties. Many ponds are on rural properties that are operated as weekend farms or country retreats by urban residents. The methods used at such farms are very basic.

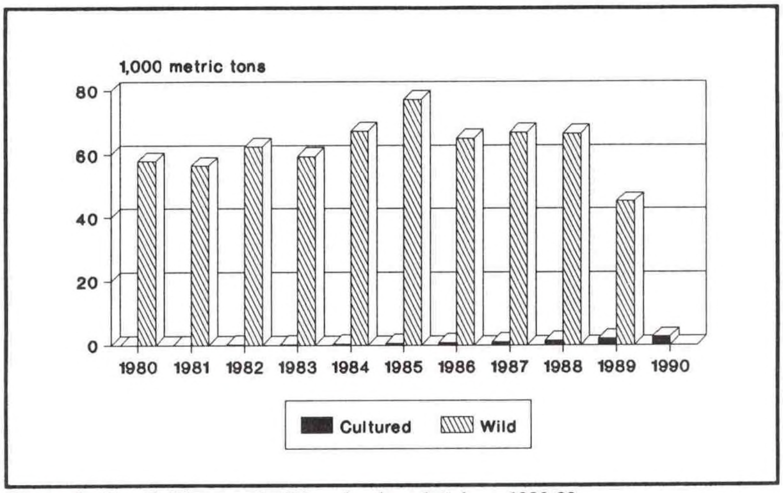


Figure 4.-- Brazil. Harvest of wild and cultured shrimp, 1980-89.

V. HARVESTS

Data on pond harvests have proven difficult to obtain. Limited data is available through IBAMA. The authors of this report, however, have relied primarily on industry sources and various consultants.[62] As a result, there are substantial discrepancies between sources. This has made it extremely difficult to track the industry's progress with any precision. While the actual numbers may vary, the same basic pattern emerges in most assessments. Brazilian shrimp farmers have been plagued with a continuing stream of difficulties. Despite considerable Government support and a decade of effort, the industry is just beginning to reach some conclusions on species and growout methods best suited to local conditions. While cultured harvests are still limited and only a small part of Brazil's overall shrimp production (figure 4), observers confirm that the industry is reporting progress and harvests appear to be increasing. Not all observers are convinced, however, and some are skeptical of available harvest estimates.

A. Marine Species

1970s: Brazil's first experiments with shrimp culture began during the 1970s. The first trials were conducted by the **Companhia Souza Cruz Industria Comercio** in Rio de Janeiro state, primarily on *P. schmitti*. Other trials were conducted in Pernambuco, Rio Grande do Norte, and Santa Catarina. These experimental efforts by various research groups and farmers used primitive, extensive systems. The **Empresa de Pesquisa do Rio Grande do Norte** (EMPARN) initiated some particularly important work on *P. brasiliensis*, but later reported success with an exotic species (*P. japonicus*), impressing SUDEPE officials.[63] Harvests during this period were negligible.

Early 1980s: Commercial shrimp farming began in Brazil in 1980 when the **Companhia Industrial de Rio Grande do Norte** (CIRNE) converted some of its salt ponds to extensive shrimp growout ponds. CIRNE and several other early growers decided to use *P. japonicus*. Other farms experimented with *P. japonicus* along with trials of indigenous species.[64] Preliminary results reported by EMPARN and other groups had reported that *P. japonicus* could yield good results in Brazil. This early optimism and Government financial support attracted considerable interest among investors, especially as they noted the increasing success of the shrimp culture industries in Ecuador and other countries. Several extensive farms were built in the early 1980s. SUDEPE decided to actively promote the use of *P. japonicus* in its promotional activities and, as a result, little consideration was given to assessing the potential of the indigenous species. Many of the initial projects were built in northeastern Brazil where favorable climatic and hydrological conditions suggested that the area could support a viable shrimp culture industry. Most of the early projects, however, failed to meet production goals. Lack of experience, poor farm design and site selection, inadequate management strategies, misguided Government policies, little familiarity with Brazilian culture conditions, difficulties associated with *P. japonicus*, and a variety of other problems were the principal reasons for the farm failures. Harvests were very limited during this period. While precise data is not available, harvests by 1983 probably were only about 100 tons, despite the significant Government promotional efforts (appendix E2).

1984-87: A prolonged drought in northeastern Brazil ended in 1984 when heavy rains occurred for the first time in several years. The rain altered the salinity of the water in many areas and farmers reported high mortality levels. As a result, several farms failed and the remaining ones concluded that *P. japonicus* was not suited to Brazilian growing conditions. The industry was further affected in 1985 by problems at some of the newly established

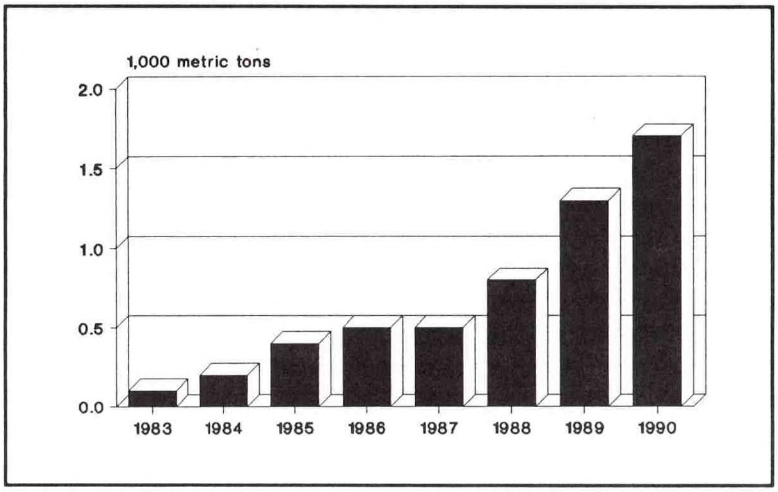


Figure 5.-- Brazil. Cultured Harvest of marine shrimp, 1983-90

hatcheries, resulting in massive pl mortalities.[65] Farmers in 1984 and 1985 expanded efforts to use a wide range of indigenous and exotic species, as well as a variety of different growout strategies and pond designs. Brazilian growers found that the extensive operations which proved so successful during the early phases of the industry's development in Ecuador, achieved extremely low yields in Brazil. Indigenous species performed poorly in Ecuadorean-style extensive operations. One factor may be the relatively low nutrient level in Atlantic-coast waters resulting in yields far below levels achieved at Ecuadorean and other Pacific-coast farms with access to richer coastal water. As a consequence of the lower than expected yields, several poorly designed and inadequately financed operations failed. Many growers concluded that extensive methods were not suited for Brazilian conditions. Marine harvests increased only marginally during this period, from about 200 t in 1984 to 500 t in 1987 (figure 5), in sharp contrast to the spectacular increases being achieved in Ecuador. Many investors began to question Brazil's ability to support a major shrimp culture industry. Regardless of the actual harvests achieved, an increasing number of Brazilian growers during this period, gained important experience with growout operations and local conditions.

1988-90: Continuing work by shrimp farmers is slowly resulting in improved yields and harvests. (See "Yields.") Growers are increasingly concluding that semi-intensive farms which provide supplemental feeding and other enhancements are much more suited to Brazilian conditions. The development of high quality feeds and feeding strategies increasingly tailored to the needs of specific species appears to be a critical requirement for the industry's future. Harvests began to show notable increases in 1988, although the overall quantities are still quite small. In addition, some observers continue to caution that few, if any, farmers have achieved profitable commercial operations.[66] While many observers believe that both yields and harvests are slowly increasing in Brazil, there is some disagreement over actual harvest levels. Some 1989 harvest estimates for marine shrimp exceeded 2,000 t, but the most likely estimate was prepared by the Brazilian Shrimp Culture Association (ABCC) which believes farmers harvested about 1,300 t of marine species (appendix E2 and G7 and figure 5).[67] Most observers are projecting a substantial increase in 1990. The ABCC believes, for example, that the 1990 harvest may reach 1,700 tons.

Despite the gains made by farmers, a substantial number of Brazil's shrimp ponds were idle in 1989 and 1990. As of May 1990, one source suggests that only about 2,200 ha of Brazil's 3,900 ha, or 55 percent, were in operation (appendix G7). Given the high cost of pond construction, this abnormally low rate of utilization has adversely affected the profitability of many Brazilian farms. The low pond use is due to several factors, including the closure of many farms, technical and management problems, and a shortage of postlarvae.[68]

1990s: Some Brazilian sources believe that growers will continue to report substantial, if not spectacular, increases for the next few years, given their increasing success in improving yields. Not all local observers, however, are so optimistic. Brazil's potential to culture shrimp is unclear as there are so many unquantifiable variables. Without knowing the area suitable for shrimp culture or the methods and species that will come to dominate the industry, estimates of Brazil's potential are mere guesses. Observers who envision a massive shrimp culture industry may be correct, but there are ample grounds for treating such projections with caution. After a decade of effort, including both private investment and some Government support[69], farmers still produce only about 1 percent of Brazil's total shrimp catch (appendix F1). Based on existing information, however, it is possible to make some conservative projections. Existing farms should continue expanding harvests during the 1990s, although the growth rate will probably not be as rapid as many would hope. Harvests of 10,000 t by 2000 are probably a reasonably conservative projection.

Photo 3.-- Brazil. Batch harvest of freshwater shrimp at the Capiatã Agũicultura farm. © Victor Wanderley, CACE

Brazilian shrimp farmers, if they develop suitable sites already identified and adopt semi-intensive methods, should theoretically be able to eventually harvest much larger quantities. Harvests of 0.1 to 0.2 million t of cultured shrimp annually may be possible if the industry successfully addresses some of its major technical problems. (See "Conditions.") If the more optimistic estimates of sites prove to be accurate, harvests could be substantially more. The higher estimates, however, at this point should be considered highly speculative. Shrimp culture is a fairly recent development in Brazil and no one yet knows what yields can be achieved or the extent to which potential sites can be developed as commercially viable farms. It is also not yet clear how President Collor's economic program will affect the industry.

B. Freshwater Species

Following the development of freshwater shrimp culture in Brazil is difficult because of the lack of annual harvest data. As a result no time-line series exists to assess harvest trends. Available information suggests that harvests were about 700 t in 1989, somewhat higher than the estimated 500 t harvest in 1987 (appendix E2).[70] A more recent assesment suggests a harvest of about 1,000 t in 1990.[71] Freshwater shrimp has been primarily cultured at small, family-owned farms. Since 1987, several companies have contracted with Israeli companies to introduce more sophisticated methods. As a result, substantially larger farms have been built or are under construction. These new projects suggest that substantial harvest increases could be achieved in 1991.[72]

VI. LEGAL FRAMEWORK

The Brazilian Government issued regulations in 1987 to oversee the country's aquaculture industry. The law includes provision for registration, fees, taxes, and incentives.[73] Brazilian fishery laws and regulations are primarily administered by IBAMA, although various ministries (Interior, the Navy, and Finance) are also involved. Various state and regional development agencies also participate. One observer believes that the legal framework currently is helping the industry to develop.[74] The Government has not yet addressed, however, a variety of problems associated with the industry, including pollution, disease control,[75] and public health.

VII. GOVERNMENT ASSISTANCE

The previous Brazilian Government's 5-year plan placed a high priority on shrimp culture. An Inter-Ministerial Commission convened to promote the development of a shrimp culture industry targeted the construction of over 110,000 ha of marine and freshwater shrimp ponds by 1995.[76] Most local observers and even some members of the commission, however, view this target as unrealistic. Aside from the question of selecting and constructing such a huge area of ponds, Brazil currently lacks the aquaculture infrastructure needed to support such a massive new shrimp culture industry. Feeds, equipment, supplies, pl seed stock, and trained managers and workers are reportedly all in short supply already, even though the total active pond area is probably less than 3,000 hectares. As a result, the Collor Government is not following the previous Administration's 5-year plan for developing the shrimp culture industry. The current fiscal crisis in Brazil is seriously limiting Government support programs in many sectors of the economy. The new Administration's policy toward the shrimp culture industry is not yet known, but officials in the Collor Government appear to be far more skeptical about the shrimp culture industry's prospects in Brazil, based primarily on the limited successes reported by growers.[77]

Various Government agencies have sponsored some research and training as well as directly promoted the industry's development.

Research: The Brazilian Government has conducted or funded shrimp culture research since 1973. Scientific research in Brazil is coordinated by the Conselho Nacional de Desenvolvimento Cientifico e Tecnologico (CNPq) composed of all Brazilian research groups receiving government assistance. While nearly 30 government agencies (federal and state) and academic groups have conducted some shrimp culture research, that activity has only begun to address the important technical problems faced by the growers.[78]

Government agencies and academic institutions have conducted or sponsored research on both marine and freshwater species.
Marine species: One of the primary Government research groups working on marine shrimp is the Rio Grande State Agriculture and Livestock Research Center (EMPARN) which has done some particularly important work on nutrition. The Santa Catarina Fishery Extension Service (ACARPESC) also conducted basic research on shrimp culture from 1972-74. The Aquaculture Department of the Federal University of Santa Catarina has done substantial work on nutrition of *P. paulensis*. The Fundaçao Instituto de Pesca do Rio de Janeiro (FIPERJ) and the Fundaçao Municipal "25 de Julho" have also conducted valuable research projects. The Comissão Executiva do Plano da Lavoura Cacaueira (CEPLAC) has participated in the country's emerging hatchery industry, although their hatchery has reported disappointing results.[79] The Rio Grande University (Rio Grande do Sul) and the Federal University of Santa Catarina have been particularly active in work on *P. paulensis*. The Oceanographic Institute at the University of São Paulo has an important program attempting to assess how to convert existing extensive ponds to more productive semi-intensive operations.[80] (See "Training") Several other universities have important research/training programs. The Instituto de Biociencias at the University of São Paulo has opened a Disease Diagnostic Laboratory, Brazil's first such facility. This new facility includes histopathology, microbiology, and molecular biology units.
Freshwater species: Scientists at the Instituto de Pesquisas Agropecuaria de Pernambuco, the Pernambuco Federal University (UFPE), the Empresa Pernambucana de Pesquisa Agropecuaria (IPA), Zootechnical Department (Aquaculture Sector) of the Federal University of Rio Grande do Sul (UFRGS), the Departamento de Aquicultura of the Universidade Federal de Santa Catarina, Aquculture Center of the State University São Paulo (FCAVJ/UNESP), and the Empresa Capixaba de Pesquisa Agropecuaria (ENCAPA) have worked on freshwater shrimp.

Many private groups have also conducted research on shrimp culture as part of their shrimp growout or hatchery operations. These researchers are assessing a variety of species, feeds, and culture systems. The work done at Maricultura da Bahia on marine shrimp and Capiata Aquicultura on freshwater species has been especially valuable.

Brazilian researchers and farmers, however, have not reached any firm conclusion on the optimal marine species or culture strategy in Brazil. As a result, there is enormous diversity among the approaches taken by various Brazilian farmers. The inability of the industry to reach firm conclusions on species, farm design, and growout strategy have significantly affected the results achieved. Each farmer has had to choose from many options. This is different from the situation in Ecuador and other countries, where species and basic growout strategies were widely accepted before many growers entered the industry. Brazilian farmers, as a result, have reported lower yields than those achieved in many other Latin American countries.

Training: Several Brazilian universities currently offer specialized degrees in aquaculture, including specialized shrimp culture programs along with research programs. Brazil has only two graduate schools specializing in aquaculture, the Federal University of Santa Catarina (Master's level) and the Aquacuture Center of the State University of São Paulo (Master and Doctorate level). Many other universities have advanced degree programs in various related fields.

Training opportunities, while still limited are expanding. In the northeast the Federal Universities of Ceara, Rio Grande do Norte, Paraiba Rural de Pernambuco, Pernambuco, and Bahia have important training programs. In the South the Federal Universities of Espirito Santo, Vicosa, Rio de Janeiro, São Paulo, Santa Catarina, and Rio Grande do Sul offer programs. Currently most of the researchers working on shrimp culture were trained as fishery engineers with specialties in aquaculture. This course of study at the B.S. level has been offered since 1974 by the Federal Rural University of Pernambuco and the Federal University of Ceara. Several other universities conduct research or offer graduate programs in shrimp culture, including: the Federal Universities in the states of Bahía, Rio de Janeiro, and Santa Catarina; the University of São Paulo; the Fundaçao Universidade do Rio Grande (FURG), and UFRGS. Probably the best training facility in Brazil is the Center for Research and Training on Aquaculture (CEPTA), located at Pirassununga in São Paulo State. Unfortunately, CEPTA focuses on freshwater finfish.

Promotion: The former Brazilian fisheries agency, SUDEPE,[81] and other government institutions have played an important role in promoting commercial development. Government credits (PROPESCA/BID[82]) and tax credits (FISET/PESCA and FINOR/SUDENE) attracted considerable interest among investors. This spurred the construction of the first commercial shrimp farms in 1980-81. SUDEPE obtained funds from foreign donors, primarily the Inter-American Development Bank (IDB). The IDB provided the Brazilian Government about $15 million to finance commercial shrimp culture projects as part of a much larger fisheries development program approved in 1980. The IDB suspended a projected second stage of its loan program, however, after farmers encountered problems and IDB officials do not currently foresee any future shrimp culture loan programs. Other Government agencies which have provided financing for shrimp culture projects include: the Superintendencia de Desenvolvimento do Nordeste (SUDENE); the Banco do Brasil; the Banco do Nordeste do Brasil (BNB); the Banco Nacional de Desenvolvimento Economico e Social (BNDES); and various state development banks. Academic groups have also played important roles providing technical assistance to shrimp farmers. In the northeast the Secretaria de Agricultura do Estado do Para and the Federal Universities of Maranhão, of Ceara, and of Alagoas also have important programs. Some observers, however, are critical of Government support programs. One observer reports that they were temporary programs mostly available through state governments which resulted in little "strategic" assistance to the industry.[83]

SUDEPE financing assisted over 40 farmers to build 3,500 ha of growout ponds by October 1986.[84] The total amount of SUDEPE funding is not available, but one source suggested that by 1984 the agency had provided almost $23 million in low-interest loans to support the industry. The total amount must be substantially larger. Some observers initially believed that the extensive Government support would enable the industry to develop rapidly in Brazil. Results, however, have been far below expectations. Many of the SUDEPE-supported farms failed and by early 1990 only 20 marine shrimp farms were active, with a total pond area of about 2,200 hectares (appendix G7).[85] Many of the farms operating in 1990 are newly constructed farms, established without any government assistance, either fiscal incentives or low interest loans.

Brazilian officials have been disappointed by the failures and closings of many farms and the slow pace of the industry's development. Some of the difficulties appear to be related to the **Brazilian Government's initial promotional policies**. One author claims that the availability of credit at below-market rates may have attracted investors not fully committed to the industry or with limited technical competence.[86] Some investors apparently sought low-interest Government loans so that they could deposit the funds temporarily at high interest rates before they needed to make payments on their shrimp culture projects. The below-market rates may have encouraged many investors to enter the industry with insufficient attention to site selection, pond design, and building costs. Many farms built during the early stages of the industry's development were reportedly **poorly designed** and located on less than optimal sites. Tax concessions offered by the Government also may have encouraged investors to commit funds without adequate research. Most of the early investors were businessmen with no **technical competence** in aquaculture. Some were already experiencing financial problems with other investments and looked at aquaculture as a way to raise money. Many did not give their shrimp culture investments the necessary attention. Such investors reportedly acted as if the funds obtained were not their own and were not as careful as they might have been with loans secured on commercial terms.

Perhaps for this reason, some Brazilian growers have reported construction costs over $20,000 per ha, the highest in Latin America.[87] Actual costs probably should not have exceeded $5,000-10,000 per hectare. With such costly ponds, farmers would have had to achieve very high yields to sustain their operations. Most early farms, however, achieved very low yields. Despite their cost, ponds were often poorly designed and situated at inappropriate sites. Such farms have proved impossible to operate successfully. These difficulties were compounded by serious management problems. Few of the investors had any idea of the complexity of the operations or technical expertise required[88]. Several companies built luxurious offices in cities and seldom visited their shrimp farms. Such practices often led to commercial failures. These and other experiences partially explain the ensuing disenchantment with the industry.[89] Some observers continue to question the Government's development policies. Many in the industry have especially criticized the continued funding of commercial farms while curtailing research and training programs.

The Brazilian Government's disappointment with previous programs to promote the shrimp culture industry caused it to reassess those efforts. Officials decided that while the initial promotional program had not worked, the industry merited continued Government assistance. As mentioned above, an Inter-Ministerial Commission was established to develop a new Shrimp Culture Assistance Program in 1988. The program was to have been conducted under the auspices of the National Irrigation Program.[90] The Government's program targeted northern and northeastern Brazil and envisioned the construction of over 110,000 ha of ponds. The program was presented at the III Simposio Brasileiro Sobre Cultivo de Camarão during October 1989 and reportedly generated considerable interest. Some local observers, however, are skeptical of the Government's expansive plans, maintaining that very little consideration has been given to providing the infrastructure needed to support such a massive expansion program.[91] The Collor Government is not implementing the plan and future Government policy towards the industry is unknown at this point. The country's current fiscal situation will almost certainly constrain Government promotion efforts.

Several industry sources have sharply criticized SUDEPE's successor agency, IBAMA. The new agency is responsible for a variety of natural resources in general and, as a result, does not have the focus on fisheries which SUDEPE once had. Financial assistance to the industry has been substantially reduced. Industry observers also complain that IBAMA has not yet resumed the collection and collation of basic statistical data. In fairness to IBAMA, Brazil's financial problems have resulted in substantial reductions in Government programs. As often occurs in resulting economy drives, funding for relatively unglamorous activities such as statistical programs, have been cut.

Government agencies can play an important role in the shrimp culture industry beyond direct promotion and fiscal incentives for farm projects. Important activities include encouraging research and training, regulating the industry, disseminating information, and establishing extension programs.[89] Other important activities such as basic infrastructure development could assist farmers. While various Government agencies have initiated a variety of programs, much remains to be accomplished in research, training, extension services, and infrastructure development. One observer suggests the creation of an effective Government assistance program like the ones initiated in some other countries (Indonesia, Taiwan, and Thailand). Such a program would include the establishment of a national-regional shrimp culture policy to coordinate local research and training, and provide long-term financial assistance.[90]

VIII. METHODS

A. Marine Species

Brazilian marine shrimp farmers use a wide variety of methods and species. An excellent review of industry practices based on extensive field visits in 1988 was prepared for FAO with the financial support of the Italian Government.[91] The industry is currently in a transitional phase from the extensive methods widely used in the earlier farms to the higher yielding semi-extensive and semi-intensive methods being employed at the newer farms. Many of the older farms, especially those with particularly large ponds, are difficult to convert without major new expenditures for constructing smaller ponds and installing added channels to increase water exchange and improve drainage. Overall, both extensive and semi-intensive farmers, however, have reported discouraging results. One observer lists some of the principal reasons for the poor performance: 1) lack of technical knowledge; 2) limited efforts to obtain advanced technology; 3) inadequate pl supply; 4) poor quality feed; 5) high feed costs; 6) low prices received for small shrimp harvested; 7) poor management practices; and 8) various other problems.[92] Farmers are now reporting improved results, but a wide range of opinions exist among local observers concerning the extent of that improvement.

Extensive operations: Brazil's shrimp culture industry generally developed using basic technology. One observer described many farms as "rustic operations." Most of the initial farms employed extensive methods, and a large number of farms continue to do so. Ponds varied from 5 to as many as 100 hectares. Currently, however, few farms operate ponds larger than 25 ha and most of the larger ponds are now inactive. Most have pumping stations and central canal systems to exchange about 5 percent of the water volume daily.[93] The extensive farms using low stocking densities (less than 2 pl/square m) and exotic species generally achieved disappointing results. One observer reported that many of the extensive farms he visited in 1987 were achieving yields of only about 0.2 t per harvest. Most were losing money, especially those operations which included costly hatchery facilities.[94] As a result, the industry has gone through a period of consolidation, and many of the original farms are no longer operating. SUDEPE sources estimated that only about 21 farms were operating in 1987, most of which were employing extensive methods (appendix G2). Few of the farms using extensive methods are achieving profitable operations. Many farmers have concluded that such methods are simply not suited for Brazilian conditions. One expert at the University of São Paulo insists that extensive operations can prove successful in "only restricted cases."[95] Many farms have shifted to what Brazilian farmers refer to as semi-extensive operations (appendix I2), which are in fact primitive semi-intensive systems.[96]

Semi-intensive operations: A few years ago there was relatively little interest in semi-intensive methods

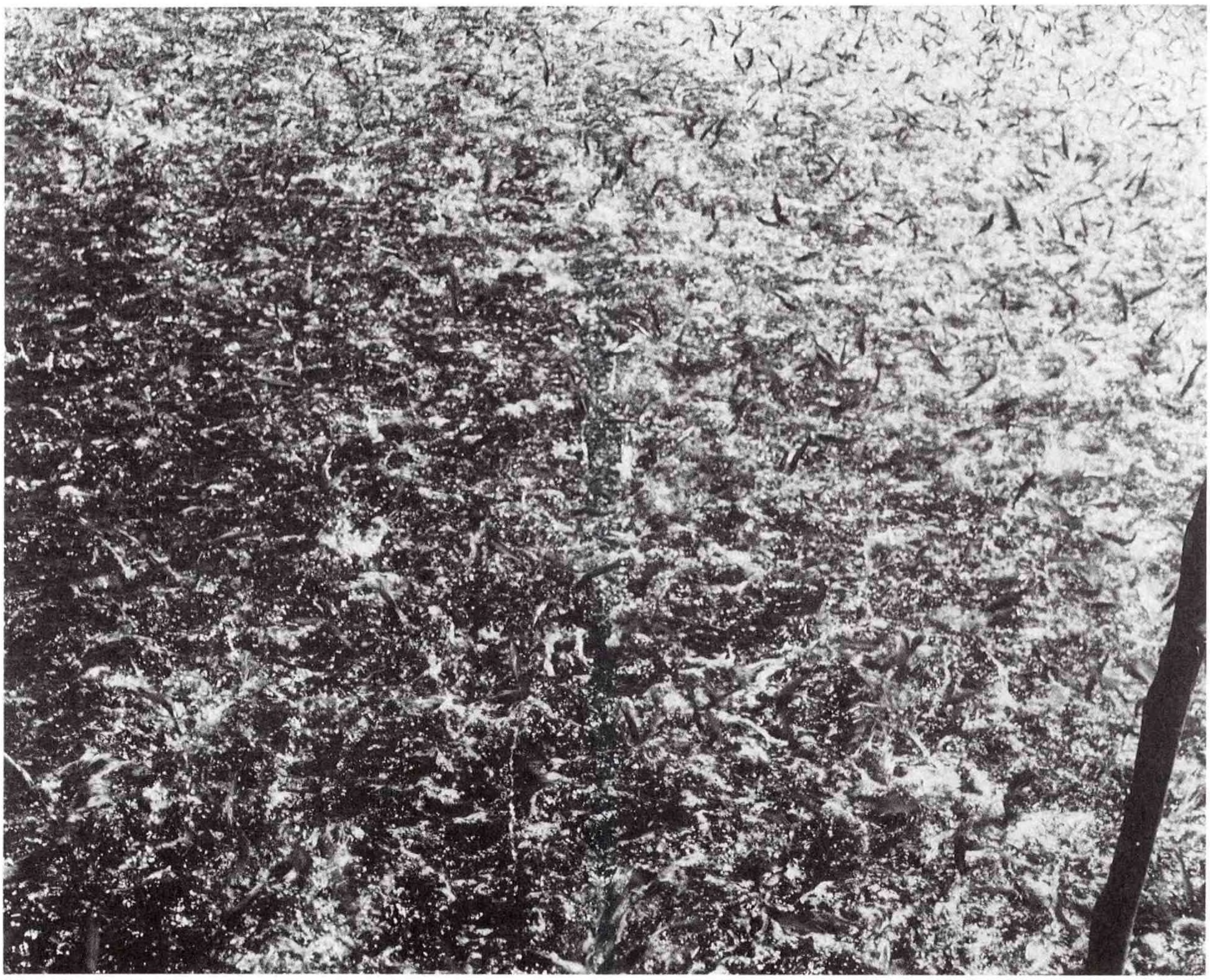


***Photo 4**.--Brazil. Shrimp jumping on the surface at the end of a pond harvest. © Moacyr Araujo, Maricultura de Bahia*

and only a few farms utilized such methods. One 1987 estimate found that 10 groups had initiated or were planning to build primitive semi-intensive farms (appendix G2). Brazilian farmers are now gradually shifting to semi-intensive operations. The tendency to increase stocking densities, build smaller, more manageable ponds, apply supplemental feeding, increase water exchange, etc. are all part of that gradual shift. Local observers report that by 1990, as much as half of the total pond area is being farmed using at least some semi-intensive methods.[97] Another 1990 estimate by the Brazilian Association of Shrimp Producers (ABCC) confirms that Brazil's most productive farms had adopted semi-intensive methods (appendix G6). Semi-intensive farms generally have ponds varying from 5-20 ha, but most new farms have ponds under 10 hectares. A typical operation in northeastern Brazil uses indigenous species, often *P. schmitti* or *P. subtilis*. Farmers use pl collected in the wild as well as purchased from hatcheries. Only scattered reports are available on pl prices. One observer estimates tha pl25 prices vary from $3.50-5.50 per thousand. Another estimated in 1990 that hatchery pl averaged about $5.40 per thousand, but wild pl was available for about half that amount. Many farms keep broodstock in maturation ponds until they are ready to spawn. Gravid females can be purchased relatively cheaply, for about $2-5 each. One observer in 1988 reported stocking densities between 3-5 pl per square meter.[98] Another observer reported farmers in Paraiba, Rio Grande do Norte, and Ceara generally stock at densities of 3-7 pl per square meter. Some farmers are experimenting with higher stocking densities, but the results of these efforts are not yet available.

The results that the industry will achieve by shifting to semi-intensive methods are unclear. Some farms designed for semi-intensive operations seem to be achieving acceptable yields. Many of the earlier extensive farms with large ponds, however, may not be suitable for semi-intensive operations without prohibitively expensive modifications. Proper semi-intensive pond management is not possible in large ponds. Some semi-intensive innovations such as supplemental feeding and increasing water exchange can be introduced, but results have been generally disappointing and serious problems can develop when they are employed at extensive farms. Many such farms report deteriorating water quality and bottom conditions as a result of accumulating wastes. Production costs also tend to be relatively high as it is difficult to control feeding in large ponds and in many cases this has led to excess feed applications.[99]

Operating procedures vary a great deal from farm to farm. In general, however, several observers have reported that Brazilian farmers generally do not collect basic data needed to make informed judgements on farm management. Few farms, for example, maintain detailed records on pond temperature, dissolved oxygen, salinity, turbidity, pH levels, or various chemical parameters.[100] Such data is imperative for daily pond management. The failure to keep such records has greatly complicated the development of optimal growout strategies. The problem is partly due to the shortage of trained technicians and pond managers. It is also due to the lack of interest by owners in pond management, some of whom do not understand basic principles of growout operations. Many investors are primarily interested in controlling costs and seem unwilling to hire trained specialists or additional staff to collect the needed data. Many farms do not even have the basic equipment needed to collect data.

B. Freshwater species

Freshwater techniques are more widely standardized in Brazil, much more so than marine culture techniques, mainly because freshwater shrimp culture operations primarily use one species, *M. rosenbergii*. Freshwater ponds can compliment other agricultural activity. Unlike marine ponds which have high salinity effluent, freshwater pond effluent can be used in conjunction with irrigation or safely fed back into rivers. Many growers in northeastern Brazil use the continuous culture system where juveniles are continually stocked and the larger individuals culled.[101] Most groups have adopted batch culture methods in which the ponds are stocked and a crop harvested after a specific time.[102]

Extensive farms: Most extensive operations are conducted on small, family-owned farms. Each farm commonly has a nursery pond (usually about 10 percent of total pond area) in which pl are stocked for 30-40 days at high densities (70-120 pl per square m). Pl prices according to one observer in Rio Grande do Sul are generally about $18 per 1,000 postlarvae.[103] After the nursery stage the pl are stocked in small ponds at densities of about 10 pl per square meter and finally juveniles are stocked in growout ponds at about 5-7 pl per square meter. Individual growout ponds are usually about 0.5-1.0 ha. Farmers harvest their shrimp monthly on a selective basis, unlike marine shrimp ponds where the entire pond is usually drained. Some farmers begin harvests after about 6 months and then every 1 or 2 months add small numbers of pl, about 0.5-1.0 pl per square meter.

Semi-intensive/Intensive farms: A few Brazilian farms use semi-intensive and intensive methods. Various Israeli groups are playing a key role in Brazil's development of a modern freshwater shrimp culture industry by introducing more sophisticated methods to Brazilian farmers. One of these farms is located in Alagoas State and has only recently begun operating using Israeli hatchery and growout technology.[104] The company reports annual yields of 3.2 t per hectare.[105] That same farm experimenting with batch culture methods reported annual yields of 2.2-2.7 t per hectare.[106] The most recent reports suggest that in 1990 the company was achieving annual yields of 3.9-4.2 t per hectare.[107] The company plans to increase its 54 ha of ponds to 100 ha by the end of 1990. A new farm project near São Paulo (Ideadeco Agro Industrial y Alimenticion) will be based on Israeli technology.[108] It covers an area of 220 ha and plans to harvest 620 t annually.[109] If successful, these farms would significantly increase Brazil's harvest of freshwater shrimp. Ideadeco/APT plan two additional projects. One Ideadeco project is in São Paulo State (Ribeira Valley) and is based on a polyculture system (freshwater shrimp and tilapia) where associated growers are organized around a central farm. Ideadeco, operating the central farm, would provide all-male tilapia fry and juvenile shrimp, feed, laboratory and extension support, as well as marketing services for the harvested product. Another new Ideadeco project is planned for Bahia State (São Francisco River). It will be a 50 ha combined freshwater shrimp/tilapia farm. The farm will be a self-sufficient intensive farm, using high water exchange rates. The anticipated annual yields will be 40 t of tilapia and 4.5 t of freshwater shrimp per hectare.[110] The ability of these farms to achieve commercial runs with the anticipated yields should be known by 1991. Adoption of the advanced methods developed in Israel[111] could permit local growers to significantly increase yields, although the profitability of such operations remains to be demonstrated in Brazil.

IX. FEEDS

An increasing number of Brazilian farmers are employing supplemental feeding. Most farmers use fertilizer in their nursery ponds. One 1988 review found that farmers were using both organic and non-organic fertilizers.[112] Organic fertilizers commonly employed included various mixes of chicken and cattle manuer, rice stalks, corn husks, and other available material. Organic fertilizers consisted of a variety of available commercial products. Fewer farmers used supplementary feeds for growout ponds, but the proportion is increasing. One 1988 report suggested that feed was available at a wide price range: non pelleted feed ($40-390 per ton) and pelleted feed ($200-400).[113] A more recent report suggests substantially higher prices, averaging about $500 per ton. One grower complains of excessively high feed prices in 1991, over $500 per ton for a 25 percent protein feed.[114] The feeding system employed varies greatly from farm to farm, but few farms have sophisticated feed management programs. Farmers using supplementary feed report using from 60-300 kg per ha monthly.[115]

***Photo 5**.--Brazil. Some farms have mechanized systems to apply feed. Victor Wanderley, CACE*

Many observers believe that the difficulties farmers have encountered in using indigenous species are largely a nutritional matter. Other factors such as proper pond design and management are undeniably important, but nutritional research may be the key to achieving improved yields with the indigenous species. Some are convinced that once the right feed can be formulated and appropriate feeding strategies developed, several of the indigenous species will prove suitable for pond culture. Several universities and other research groups are addressing the shrimp nutrition problem, but there is a shortage of technicians as well as limited funding.

The Rio Grande State Agriculture and Livestock Research Center (EMPARN) recently conducted research on the nutritional requirements of several species. EMPARN claims to have developed an experimental feed that achieved good results using *P. subtilis* and satisfactory results using *P. schmitti*. It is unknown whether the commercial results have been comparable. The Federal University of Rio Grande do Sul is working on feed for freshwater shrimp.[116] An international research program (CYTED-D Acuicultura) made up of 15 Latin American countries is promoting data exchanges, but nutrition is a difficult subject and progress has been slow.[117] One grower complains that local feeds have been formulated for *P. vannamei* instead of indigenous species, partly explaining the extensive usage of *P. vannamei*.[118]

Brazilian feed mills are beginning to take an interest in the shrimp culture industry. The first prepared feed was introduced by Purina in 1984. Purina focused primarily on *P. vannamei*.[119] Several companies (Purina, Socil, and Cargil) have produced shrimp feed. Socil has reportedly suspended shrimp feed production. A recent report indicated that only two companies are currently active. These companies claim to have developed feeds for *P. schmitti* and trials are in progress.[120] Some farmers are reportedly achieving acceptable results, but considerable additional work almost certainly needs to be done to develop the optimal feed for specific species and growing conditions. Expanding use of these feeds could significantly increase average yields in the 1990s. The quality of shrimp feeds available to Brazilian growers should increase in the next few years. One major producer of encapsulated feeds reportedly entered the market in 1990.[121] Several Taiwan feed mills, such as Hanaqua, have expressed an interest in building feed plants in Brazil, but the Brazilian Government has not granted the necessary authorizations.

Feed companies are currently limited in their ability to commit significant resources to the development of shrimp feeds. The shrimp culture industry is still very small. Feed companies have to assess the commercial risks in conducting extensive research on a new product for what is now a very small market. Feed companies point out that there are many other demands for scarce research funds from much larger sectors of Brazil's agricultural industry. Currently an impasse between the farmers and feed companies is slowing development of Brazil's shrimp culture industry. Many Brazilian farmers complain of poor quality and high costs and are hesitant to commit to semi-intensive systems until higher quality feeds are available.[122] The feed companies are not fully committed to producing such feeds as many farmers continue to cling to extensive systems which do not require feeds. Despite the difficulties, feed companies are expanding research efforts to develop improved feeds. One expert believes, however, that more effort needs to be directed at obtaining better quality ingredients, especially fishmeal. Others believe that the development of encapsulated feed will be an important step. Unconfirmed reports suggest that the Government has decided to allow the importation of balanced feed which will provide farmers access to major feed companies, although the economics of importing feed are not known.

Obtaining adequate supplies of fishmeal may eventually prove to be a problem for feed companies. Brazil produced about 30,000 t of fishmeal in 1988, about two-thirds of which was used in the domestic poultry and livestock industry and about one-third exported.[123] While supplies are adequate for the small amount of shrimp feed currently produced, they would not be adequate to supply a major shrimp aquaculture industry. Fishmeal could be imported, but this would increase costs and put Brazilian growers at a competitive disadvantage to growers in Ecuador and other countries which produce fishmeal domestically. Brazil is a major producer of soya which is a potential protein for feed. Considerable research would be required, however, to produce a soya-based feed that would give acceptable yields. One alternative may be fishmeal/soya blends. Feed costs will become an increasingly important factor as Brazilian growers expand operations and more widely adopt semi-intensive methods.

The feed problem is critical to the industry's development. Not only is the formulation of feed with the appropriate nutritional characteristics important, but it also essential to develop effective feeding strategies. Feed at semi-intensive farms can total as much as half of the farms' operating costs. The efficient application of feed is necessary to keep production costs at competitive levels.

X. YIELDS

A. Marine Species

Brazilian marine shrimp farmers have been reporting yields below those of some other Latin American countries. Most growers found that their initial yields were far below expectations.[124] Such disappointingly low yields were primarily due to the Brazilian emphasis on extensive farms and the tendency to use exotic species and adopt culture systems developed in other countries with conditions inappropriate for Brazil. The lack of experience of Brazilian farmers, poor performance of indigenous species, inappropriate government policies, and other problems also caused difficulties. (See "Conditions.") Two excellent assessments have been prepared on Brazilian farms, describing these and other problems.[125]

Extensive farms: Farmers using extensive methods reported yields as low as 0.2 t per ha, although yields as high as 0.6 t per ha were also reported (appendices G2, G5, and G6).[126] IBAMA reports that farmers using indigenous species have averaged about 0.4-0.5 t per hectare.[127] EMPARN and SUDEPE surveyed 11 operational marine shrimp farms with 2,100 ha of ponds (including CBA) in 1987. The study reported average annual yields of less than 0.4 t per ha, and only one farm with yields exceeding 0.6 t per ha (appendix G2).[128]

Semi-intensive farms: Many farmers are turning to semi-intensive operations to increase yields. Some, but not all, reports suggest substantial improvement. Yields at semi-intensive farms vary from 0.7-1.5 t per ha (appendix G6)[129]. The large variation in semi-intensive yields is primarily due to the use of a wide-variety of species and culture techniques as well as a general unreliability of existing data.[130] The lack of high quality feeds and the often informal approach by farmers to feeding has been another serious problem.

Overall assessments of Brazilian marine shrimp yields vary significantly. While most farms are still extensive, which brings down the overall average, industry sources generally claim that yields are rising. One observer reports yields ranging from 0.1-1.2 t/ha in 1987 (appendix G2). Ecuadorean expert, Yosuke Hirono, prepared an excellent review in 1988, compiling data from several farms. He reported that yields continued to be far below expectations, averaging only about 0.24 t per ha in 1988, a slight decline from the 0.30 t per ha he estimated for 1985.[131] More recent reports suggest generally improving results. A 1988 study surveyed 17 farms and found yields from 0.3-1.5 t per hectare.[132] Another observer reports yields varying from 0.25-1.63 t per ha and an average of about 0.6 t per hectare.[133] Still another estimates that average yields have increased sharply from 0.60 t per ha in 1989 to 0.75 t/ha in 1990.[134] IBAMA calculates that Brazilian farmers achieved annual yields approaching 0.8 t per ha in 1990 (appendix F3) which would mean that they have achieved levels rivaling Ecuador.[135] One industry observer writing in early 1990 estimated that the average yield for the marine shrimp culture industry as a whole was 1.0 t per ha, and 1.5 t for those farmers using semi-intensive methods.[136] While relatively few farms are truly semi-intensive, several of the large, more successful farms do use some semi-intensive enhancements. The two large farms in Bahia (Maricultura da Bahia and PESCON), for example, report annual yields of 0.6-1.2 t per ha, depending on the year and source (appendices F3, G5, and G6).

B. Freshwater Species

Freshwater shrimp yield estimates also vary. One source suggests that yields average 1.2-1.8 t per ha annually,[137] while another observers believes annual yields vary from 0.5-4.0 t per ha and average about 1.8 t per hectare.[138] Still another source reports that the main producers in the São Francisco River Valley report annual yields of 0.5-2.0 t per ha, but average about 1.8 t per hectare.[139] Others doubt that farmers are achieving annual yields averaging nearly 2.0 t per ha and suggest an average of about 1.0 t per ha is more likely.[140] Researchers in southern Brazil reported yields of 0.6-1.5 t per ha, but many part-time operators reported much poorer results.[141] Some of the farms the Israelis are working with report particularly good yields. The Capiata Aquicultura farm in Alagoas, for example, reported yields of 3.2 t per ha in 1989 and up to 4.2 t in 1990.[142] Some researchers have noted that farms using continuous harvest methods report a declining yield over time. Work being done by APT to employ batch harvest techniques may permit farmers to maintain high yields.[143]

XI. PRODUCTION COSTS

Adequate data is not available to the authors for estimating shrimp culture production costs in Brazil. The industry's slow growth rate suggests that costs may be relatively high. One observer reports that marine shrimp costs vary from $3.00-5.00 per kg, depending on the system employed.[144] One observer reports that freshwater production costs are somewhat less. Another report from southern Brazil, however, suggests freshwater production costs also vary from $3-5 per kilogram.[145] Farmers receive about $6.00 per kg for marine species, so some could theoretically achieve profitable operations. IBAMA believes that the few currently profitable farms are achieving profit margins of about 20 percent.[146] Other observers, however, are doubtful of such optimistic assessments on the profitability of current farms.[147] IBAMA believes that high margins are needed if the industry is to expand.[148] Declining world shrimp prices, however, have adversely affected margins at existing farms and discouraged some potential investors.[149] A recent survey of factors to consider in assessing shrimp culture projects in Northeastern Brazil provides a useful analysis for potential investors.[150]

XII. COMPANIES

Various sources suggest that many Brazilian companies have begun to master some of the operating and/or financial problems which beset the early entrants. The United States Embassy reported in 1987 that some farms had achieved their first profits. Some observers in 1989 and 1990 have reported increasing successes by Brazilian farmers. It does appear that several companies, particularly those companies which have built farms in the past few years, are achieving commercial success. While these reports are encouraging, it is still too early to conclude that the industry has resolved the many difficult issues that have impeded its development. Continuing reports of farm closings suggest that the industry continues to face many unresolved problems. Details on individual companies are available in appendices G2, G3, G4, G5, G6, and G7.

A. Active farms

Brazil's single most important farm is Maricultura de Bahia:

Maricultura da Bahia (MB) was the first important Brazilian farm to adopt semi-intensive methods. MB began construction in 1981 and opened its first farm at Valença in 1984. A second farm has been subsequently acquired at Salinas de Margarida. (See PESCON.) It also built the first commercial maturation hatchery and contracted a U.S. company for technical assistance. While not without a variety of operating problems, MB has conducted some of the most important research on both indigenous and exotic species. The Valença farm has about 500 ha of growout ponds making its the largest farm in Brazil (appendices G5 and G6).[151] The farm has a processing plant capable of packing 8 t of raw shrimp a day. It also operates the country's largest hatchery (appendix H3). A recent report indicates the hatchery has a capacity of over 20 million pl per month.[152] The company reintroduced *P. vannamei* to Brazil in 1984-85[153] and has experimented with four other species as well. The company decided, however, for unexplained reasons, to focus on exotics.[154] Its hatchery began experiencing severe technical difficulties in 1987. Bacterial and viral outbreaks reduced pl production. MB claims that hatchery modifications have corrected the problem, and by October 1989 the company reported hatchery production of 13 million *P. vannamei* pl in September 1989.[155] Some observers, however, believe company-supplied estimates may be overly optimistic and that MB, like many other companies, still has some serious problems. MB harvested about 400 t of shrimp during 1989, about the same as in 1986. Company officials hope to significantly increase production and harvest about 600 t in 1990 (appendix G7). Recent information from MB indicates the ponds are being stocked at 10 juvenile *P. vannamei* per m^2 for a 100-day growout cycle. Yields per crop are about 0.9 t per hectare. MB also stocks *P. penicillatus* for a 90-day growout cycle yielding 0.5 t per hectare for each crop.[156]

Other active farms[157] of interest include:
Aquamaris located near Joao Pessoa in Paraiba state was financed by SUDENE and opened in 1986. It increased pond area from 80 to 180 ha in 1989 and harvested about 50 t of shrimp in that same year. The company has its own hatchery which supplies *P. subtilis* and *M. rosenbergii* postlarvae.

Camaroes do Nordeste(CAMANOR) also located near Canguaretama built a modern hatchery[158] in 1989 which produces 3-4 million *P. schmitti* pl per month using gravid females caught at sea.

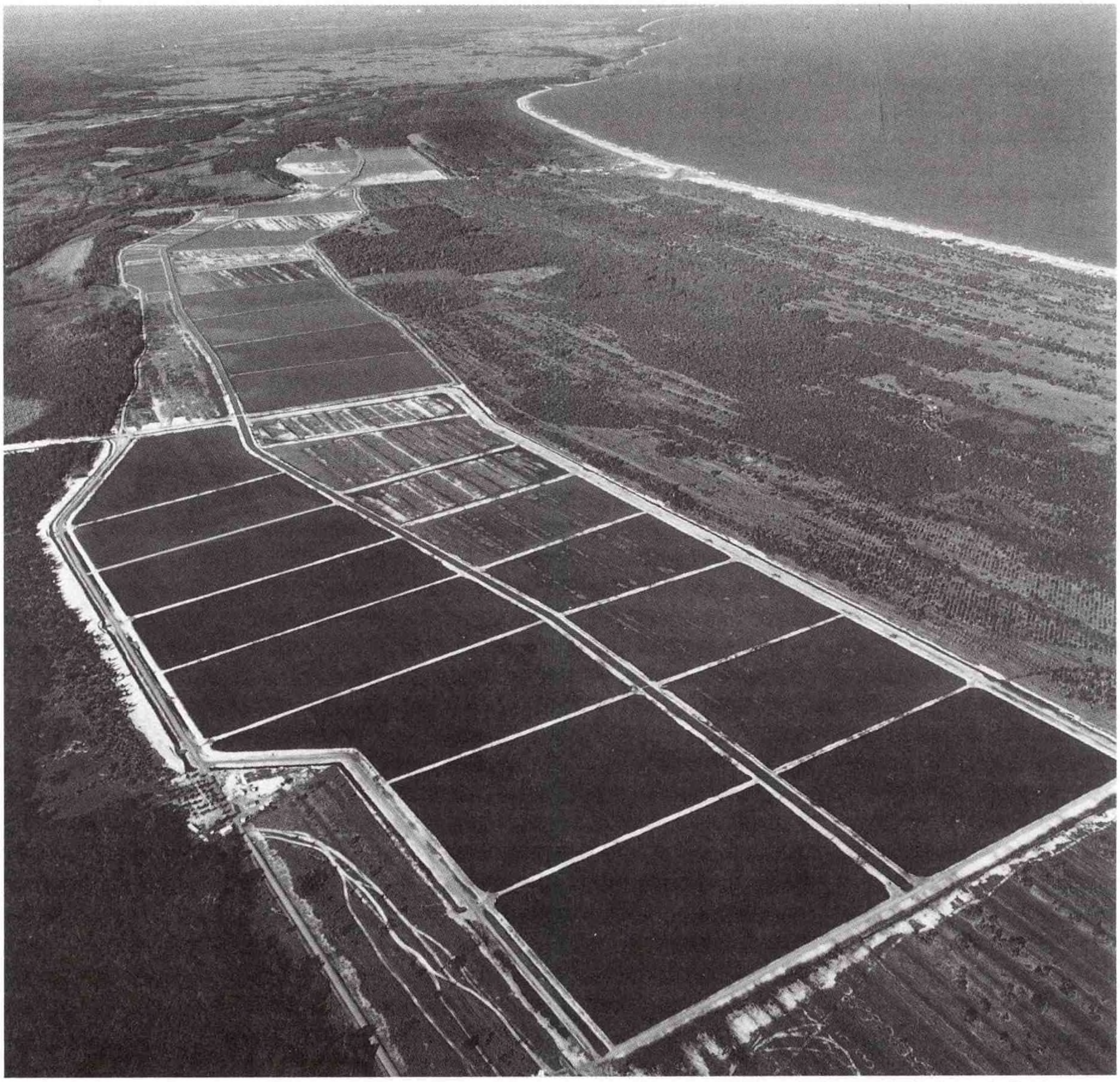


Photo 6.–Brazil. Aerial view of the 515 ha Maricultura de Bahia farm at Valença. © *Nilton de Souza, Maricultura de Bahia*

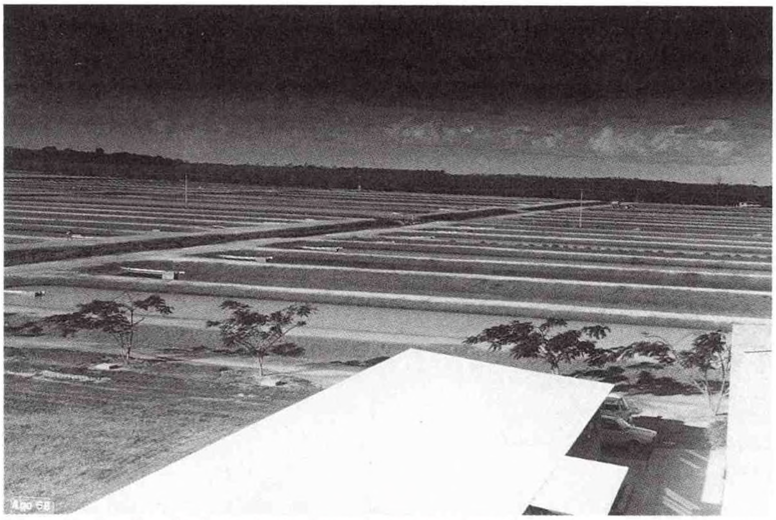


Photo 7.--Brazil. Capiatã Aqüicultura freshwater farm in Alagoas State showing 0.5 ha growout ponds. © *Victor Wanderley, CACE*

Capiata Aquicultura, Comercio e Exportaçao Ltda. is located in Alagoas, about 150 km south of the state capital, Maceio. The company has constructed 50 ha of semi-intensive ponds for freshwater shrimp in conjunction with the irrigation of a sugar cane plantation. The farm consists of 100 identical ponds of 0.5 ha each and 20 concrete nursery ponds of 0.2 ha each. The Israeli APT company has developed technology to assist farmers integrate aquaculture systems with irrigation projects. The water exchange rate is 5-7 percent and all ponds are equipped with 2 horsepower Venturi-type aerators which are mostly activated at night. The company also operates a freshwater shrimp hatchery.[159] Capiata conducts a variety of important research on improving freshwater shrimp yields. Some of the work underway is on batch culture techniques.[160] Other research focuses on stocking all-male freshwater shrimp in growout ponds. The trials are based on a series of experiments by APT in which juvenile males were sex-reversed into fertile neo-females and mated with normal males to yield all male progeny.[161]

CINE operates 80 ha of ponds in Ceara. The company opened in 1984. CINE concentrates on *P. subtilis* and reported a 1989 harvest of 64 tons.

Fazenda Perizes is another of Brazil's larger farms, operating 250 ha of ponds in Maranhão. The farm opened in 1987 and uses *P. schmitti* and *P. subtilis*, achieving annual yields of about 0.6 t per hectare. The 1989 harvest was about 90 t, but company officials hope to harvest 110 t in 1990.

Lusomar opened in 1984. The farm primarily stocks *P. schmitti*, but also uses *P. brasiliensis* and *P. paulensis*. The 1989 harvest from 100 ha of ponds was about 90 tons.

Marina Maricultura located at Canguaretama in Rio Grande do Norte state operates 70 ha of ponds, but plans to build 50 ha more in 1991.

Paludo Agropesca in Santa Catarina is one of the most southerly located farms, but reports extremely high annual yields of 1.5 t per hectare. The farm opened in 1986. The company has 150 ha of ponds and farms primarily *P. schmitti*, although another source suggests it also uses *P. paulensis*. The 1989 harvest totaled 80 t which the company hopes to increase to 90 t in 1990.

PESCON is Brazil's second most important shrimp farm, and is also located in Bahia, near Salinas da Margarida. The farm is owned by Maricultura da Bahia and operates 240 ha of ponds. It reported a 1989 harvest of 100 tons, mostly *P. schmitti* and *P. vannamei*. Annual yields from active ponds were about 0.8 t per hectare. Company officials hope to increase the harvest to 160 t in 1990. PESCON has a hatchery capable of producing 8 million pl per month. Due to local conditions and farm layout, MB stocks the PESCON farm at a much lower density (5 juveniles per m^2) than its Valença farm. As a result, the yield is only about 0.4 t per crop per hectare.[162]

Pesquera Capanema is the largest farm in Ceara. It has about 200 ha of ponds and has reported improving yields in recent years. The company still uses extensive methods to farm *P. schmitti* and *P. subtilis*.

SECOM-Aquicultura opened its farm in 1984 and now operates 200 ha of ponds in Piaui. It reports relatively low yields of 0.4 t per ha using *P. schmitti* and *P. subtilis*. The 1989 harvest totaled 53 t, which the company hopes to increase slightly in 1990.

B. Inactive farms

The **Compania Industrial do Rio Grande do Norte** (CIRNE) established one of the largest farms in Latin America on 800 ha of salt evaporation ponds in the early 1980s.[163] CIRNE sold the farm to **Compania Brasileira de Aquicultura** (CBA) in 1986 after

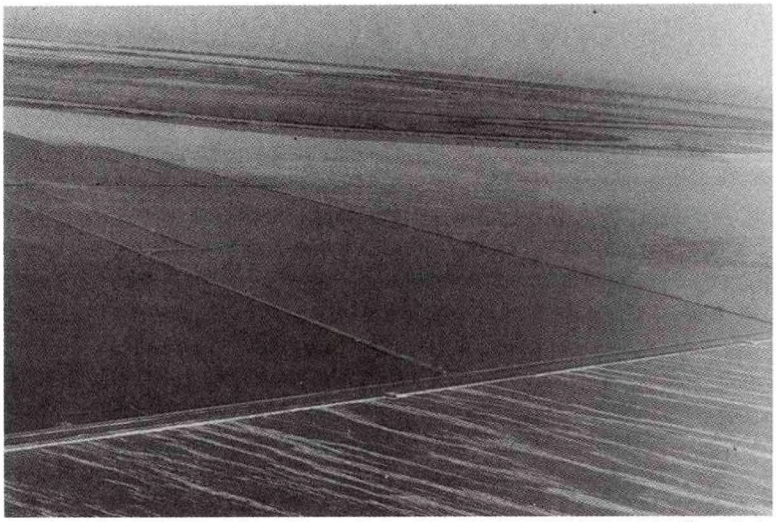


Photo 8.--*Brazil. Aerial view of an extensive Penaeid farm at Macau, Rio Grande do Norte. © Jomar Carvalho Filho, Panorama da Aqüicultura*

Photo 9.--*Brazil. Growout ponds at the EMPARN government research station in Rio Grande do Norte. © Jomar Carvalho Filho, Panorama da Aqüicultura*

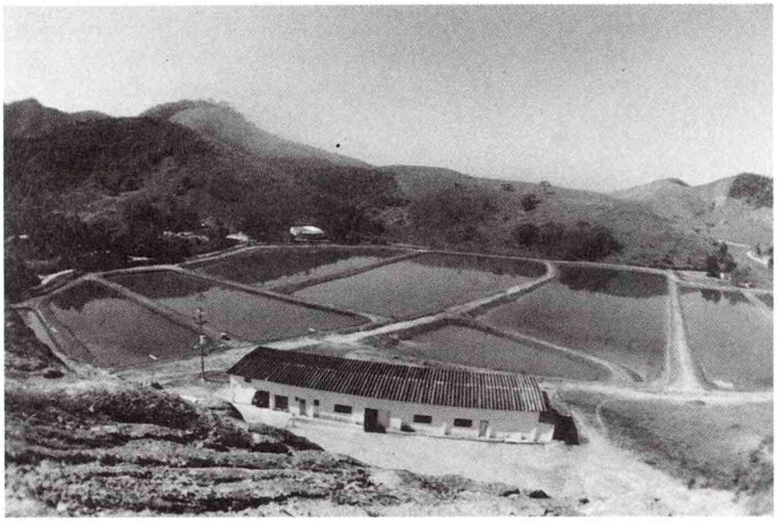


Photo 10.--*Brazil. Small 8-ha freshwater shrimp farm at Xerem, Rio de Janeiro. © Jomar Carvalho Filho, Panorama da Aqüicultura*

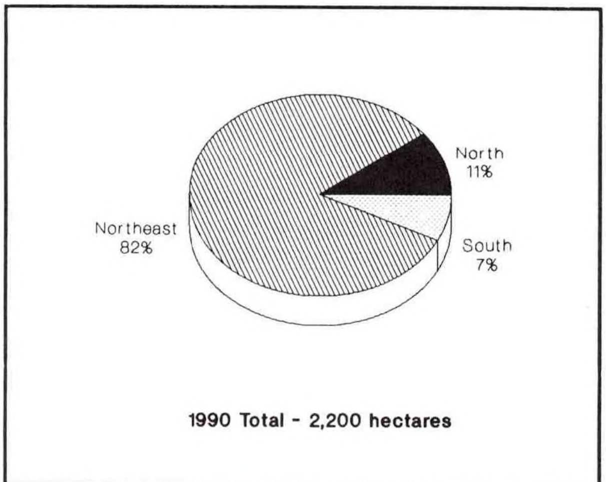


Figure 6.--Brazil. Shrimp pond area, by region, 1990.

achieving disappointing results. Continuing problems led CBA to convert the ponds back to salt production in 1987, which have reportedly proven more profitable.

Two fairly large farms are currently inactive. **Crustaceos do Brasil** (CRUSA) in Piaui built 240 ha of ponds. The company used P. subtilis, but reported yields at its extensive farm of only about 0.2 t per ha in 1989 and as a result closed. **Valença Camaroes** in Bahia built 300 ha of ponds.

XIII. REGIONS

Northeastern Brazil will probably prove to be the center of Brazil's shrimp culture industry. The situation in each region is summarized below[164].

Northern Brazil: Few investors have built sites in northern Brazil (figure 6 and appendix F3). The isolation of the northern states and limited development of needed infrastructure makes construction very expensive.[165] Some observers believe, however, there is considerable potential in the north. Maranhão probably has the greatest potential (appendix E1).

Northeastern Brazil: Most of Brazil's shrimp farms are located in the northeastern region of the country (fig. 6), especially Piaui, Ceara, Rio Grande do Norte, and Bahia. (appendices E3, F3, G1, G3, G7, and G9). Farmers in this region believe that they will be able to harvest as many as three crops per year. Precise details on the industry's status in each state are unclear, however, as different sources give different data on area of ponds, yields, and harvests (appendices G7 and G9).

Bahia: Bahia is currently the most important state for farming shrimp in Brazil (figure 7). Various observers believe that some of the best sites in Brazil are located in the state.[166] About 10 farms operate 800 ha[167] of ponds, more than a third of the country's current pond area. Plans call for the construction of another 2,000 ha of ponds. Two of Brazil's leading farms are located in the state, **Maricultura da Bahia** and **PESCON**. About 500 t of shrimp was harvested in 1989, but this could increase to 760 t in 1990.

Piaui: Farmers operate about four farms, mostly using *P. subtilis*. The area farmed is about 300 ha and harvests of marine species totaled about 60 t in 1989.[168] **CRUSA** was one of the main farms, but as explained above, has closed. Other companies are planning major expansion programs, including up to 1,500 ha of additional ponds. Freshwater farmers in the state reported harvests of about 35 t in 1987.

Ceara: About four farms were operating in 1989 and utilized about 500 ha of ponds. Plans call for the construction of an additional 500 hectares. **Pesquera Capanema** is one of the leading farms in the state. Several farmers have initiated semi-intensive operations using *P. schmitti* and *P. subtilis*. Another important farm is Artemisa-Aquacultura which operates about 150 ha of ponds. The state's total 1989 harvest of marine shrimp was about 130 tons.

Rio Grande do Norte: This state is potentially

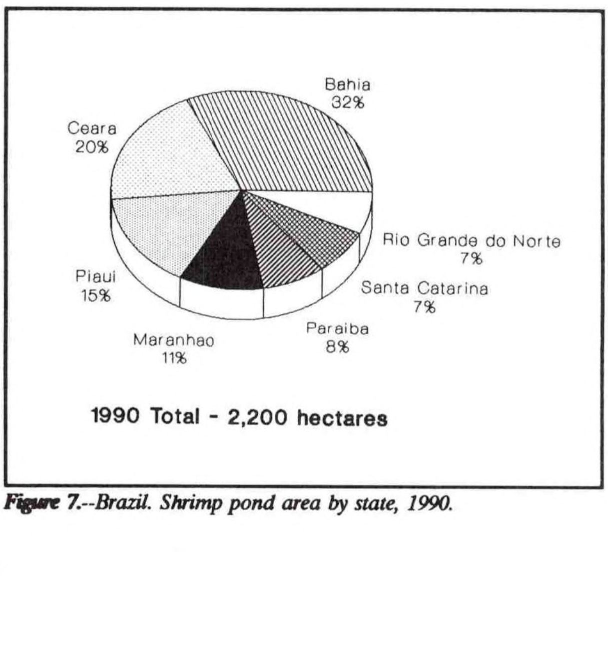


Figure 7.--Brazil. Shrimp pond area by state, 1990.

one of the most important centers for Brazil's shrimp culture industry. Several farms in the state, however, have closed. CBA, the largest company, once operated a 700 ha farm. One report suggests that the state had 12 marine shrimp farms in 1987, but only 5 actually operated. The current situation has improved and about 9 farms are operating in 1990. Harvests from 200 ha of ponds totaled about 100 tons in 1989. Plans call for the construction of an additional 1,800 ha of ponds. Two freshwater farms harvested about 37 t from 74 ha of ponds.

> Pernambuco: There are no known marine shrimp farms, but two projects are in the planning stage There are about 170 ha of freshwater ponds using a variety of systems. Yields vary from 0.2-0.8 t per hectare.

> Alagoas: There are no known marine shrimp ponds, but several freshwater farms are active. The **Capiata Aquicultura** farm is the most important. They harvested 135 t from 54 ha of ponds in 1989.

Southern Brazil: Large commercial shrimp farms have not yet developed in southern Brazil (figure 6). One observer reports, however, that their are hundreds of small growers operating with a small area of ponds (0.2-2.0 ha) scattered throughout southern Brazil (São Paulo, Paraná, Santa Catarina, and Rio Grande do Sul).[169] Harvests were probably only about 100-200 t during 1989, mostly from Santa Catarina. In the extreme south climate may restrict farmers to harvesting one crop per year. Paludo and Lusomar are the principal companies (appendix G7). A recent list of southern farms shows seven active operations (appendix G8). Some researchers believe that the potential for culturing shrimp in southern Brazil may be limited.[170] Zimmermann adds, however, that shrimp is very popular in southern states such as Santa Catarina and that the relatively high income levels there might support relatively high prices for local shrimp farmers who could supply high quality, fresh product. Yields of 1.5 t of freshwater shrimp might be competitive with much higher yields in northern states once the transportation costs are considered. Farms in Santa Catarina are mostly located on farms in marginal areas; even freshwater farms are generally located close to the sea on land that currently has no agricultural use. Current plans in southern Brazil call for the construction of only about 100 ha of additional ponds. While plans to expand shrimp farms may be limited, the local shrimp fishery could benefit from stocking pl in local estuaries. The University de Rio Grande has begun stocking *P. paulensis*.[171]

XIV. HATCHERIES

The initial decision to concentrate on exotic species has had profound consequences for the country's shrimp culture industry. The focus on exotics is probably one of the major reasons for the industry's slow progress. Even after rejecting *P. japonicus*, many farmers remain convinced that indigenous species were not suited and attempted to use other exotic species which were known to perform acceptably in ponds, primarily *P. vannamei*. Farms dependent on hatchery pl, however, are at a considerable disadvantage compared to farms in countries which have access to wild postlarvae. Hatchery pl generally cost more and often produce lower yields than wild-caught postlarvae.[172] Farm projects with hatcheries are far more capital intensive than the extensive farms typical for a shrimp culture industry in the early stages of development. The larger initial investment and more sophisticated technology required place a heavy burden on groups entering the industry, most of which have no previous experience and only limited technical expertise. Financing the added cost of hatcheries also requires farms to achieve higher yields. Such high yields, however, are generally not possible using extensive culture methods. Another problem is that hatcheries require relatively sophisticated technology. The need for hatcheries and for higher yields means that Brazilian farms required managers and technicians with a far higher degree of technical sophistication than did farms during the early stages of the Ecuadorean and East Asian shrimp culture industries. Hatchery operators have reported considerable difficulty in obtaining equipment needed at the hatcheries. Much of the equipment is not available locally and Brazilian trade and foreign currency regulations make it difficult to import.[173]

Government promotional programs have on balance adversely affected the hatchery industry's development. Government credits and fiscal incentives were an important factor for many shrimp culture projects during the 1980s. SUDEPE officials established criterion which investors had to meet to qualify for assistance. SUDEPE insisted, for example, that hatcheries be located at or near actual farm sites. Successful hatcheries, however, can not be built at every location where farms are constructed. The clustering of Ecuadorean hatcheries in Salinas

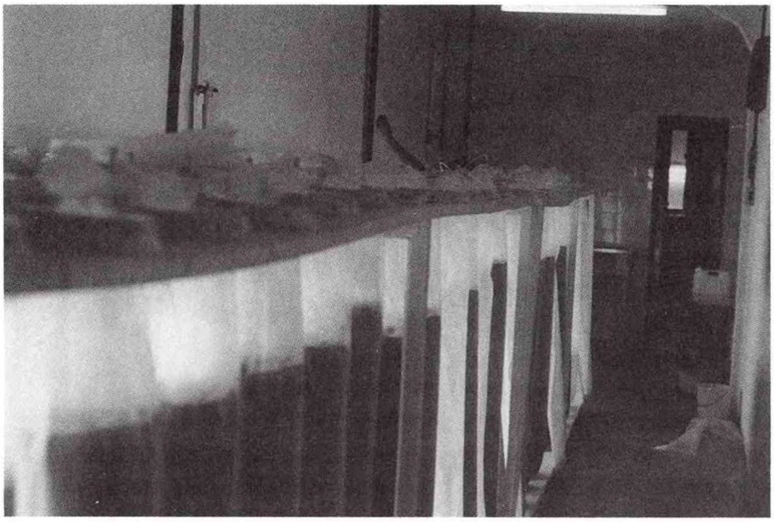


Photo 11.--*Brazil. Some hatcheries, like Aquatec, are using long plastic bags instead of breakable glass carboys.* © *Sergio Luiz de Sigueira Bueno, LPC/USP*

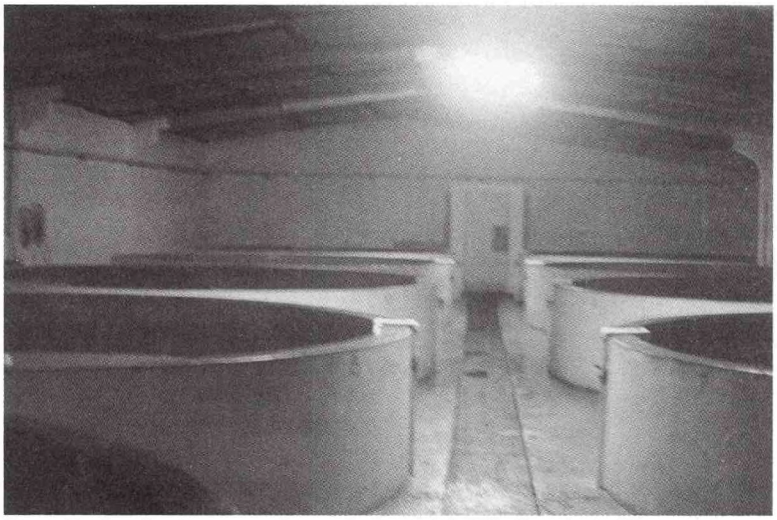


Photo 12.--*Brazil. Aquatec, at Barra do Cunhaú in Rio Grande do Norte employs an inverted photo period at its hatchery.* © *Sergio Luiz de Sigueira Bueno, LPC/USP*

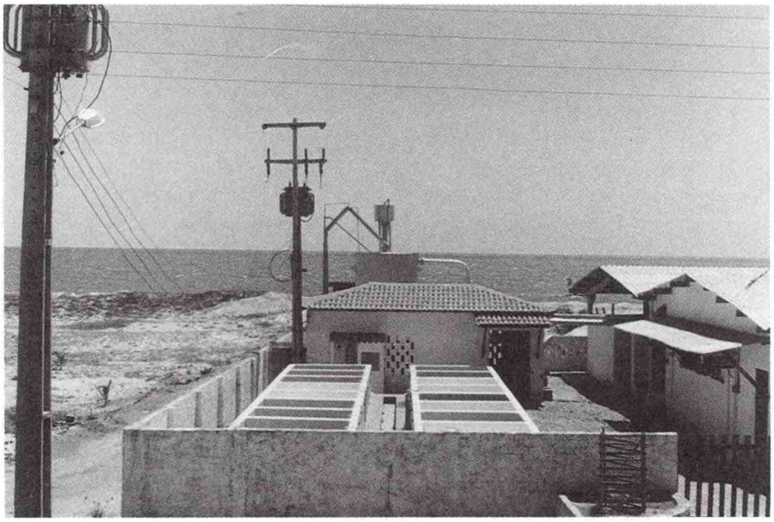


Photo 13.--*Brazil. Final step of mass algae production. Algae from the "long plastic bag" room are inoculated into outdoor tanks.* © *S.L. de Sigueira Bueno, LPC/USP*

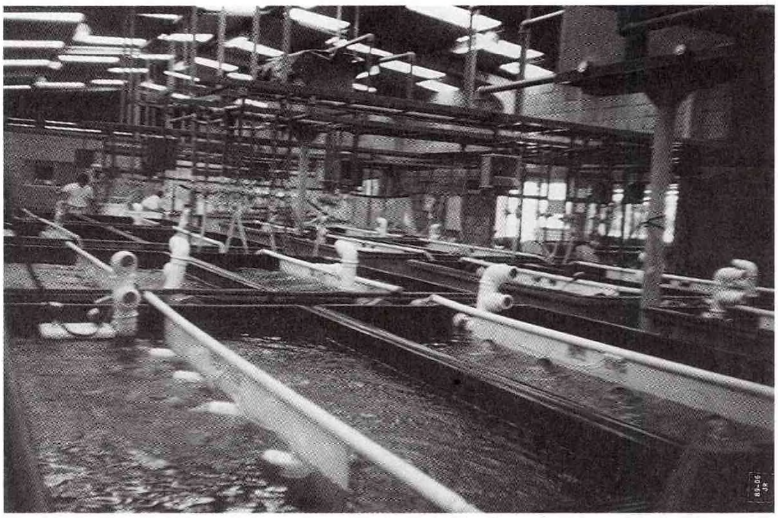


Photo 14.--Brazil. View of the modern Capiatã Aqüicultura freshwater shrimp hatchery.
© Victor Wanderley, CACE

and other locations is a reflection of the need for sites with specific characteristics, in some cases different than the requirements for shrimp growout. Hatcheries need especially high quality, pollution-free sea and freshwater. The volume of water needed is only a fraction of that needed for farms, but the water quality standards are much more stringent. SUDEPE's insistence that hatcheries be located at or near growout ponds has resulted in difficulties at many hatcheries.[174]

Brazil's shrimp hatchery industry, despite initial problems has begun to report some progress.

Marine species: Brazil reported 11-13 operational marine shrimp hatcheries in 1990 (depending on the source), with a monthly theoretical capacity of 50-90 million postlarvae (appendices H1, H2, H3, and H4). Actual production, as opposed to capacity, is unknown. Marine shrimp hatcheries apparently operate at only a small fraction of capacity. For purposes of comparison, the Inter-Ministerial Commission for Marine Resources estimated that marine hatchery capacity in 1988 was about 60 million pl per month, but actual monthly production reached only 15 million postlarvae.[175] A recent IBAMA estimate suggested that actual 1990 production was only about 20 percent of capacity, or about 15 million postlarvae.[176] A good review of the Brazilian experience with producing pl has been published by the Comissao Interministerial para os Recursos do Mar (CIRM).[177]

Freshwater species: Brazil has 23 freshwater shrimp hatcheries (appendix H5). Different sources estimate pl capacity at 22-30 million *M. rosenbergii* pl monthly, but is also not being fully utilized. Actual production is only about 8 million pl per month. Freshwater hatchery technology is simpler than that for marine species and freshwater hatcheries are reportedly experiencing fewer technical problems. One of the more modern facilities is Capiata Aquicultura, which operates a closed cycle hatchery producing 1.8-2.0 million pl per month in 24 tanks equipped with biofilters. The hatchery also has six concrete nursery ponds for pl adaptation.[178]

Brazilian marine hatcheries continue to work on a large range of species. Varied requirements for each species complicate hatchery operations. While hatchery procedures for some species such as *P. vannamei* have been extensively researched, procedures for many of Brazil's indigenous species have not. At least two hatcheries, including the large Maricultura da Bahia hatchery, give special attention to *P. vannamei.* Although *P. vannamei* pl production was less than 5 percent of the total Brazilian marine hatchery output in 1988, it represents 33 percent of Brazil's 1990 marine capacity (figure 8). Despite the attention to *P. vannamei*, about half of hatchery pl production is indigenous species, especially *P. subtilis*. *P. subtilis* (33 percent) and *P. schmitti* (17 percent) are the most important indigenous species in terms of hatchery capacity, but Brazilian hatcheries produce *P. paulensis* (11 percent). Hatcheries also work on another exotic species, *P. penicillatus* (16 percent), as well as conduct experimental runs on other species (appendix H1).[179] The largest single hatchery is Maricultura de Bahia with a capacity of about 10-17

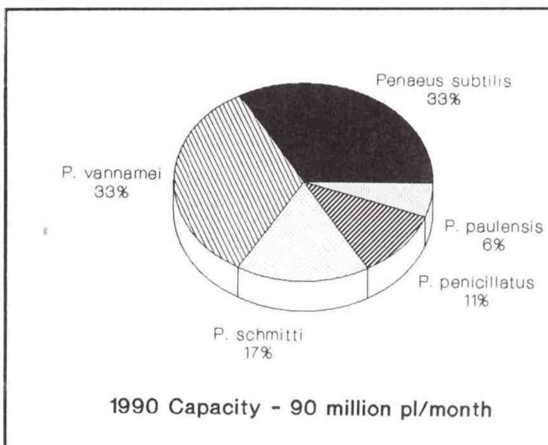


Figure 8.--Brazil. Hatchery capacity by species, 1990.

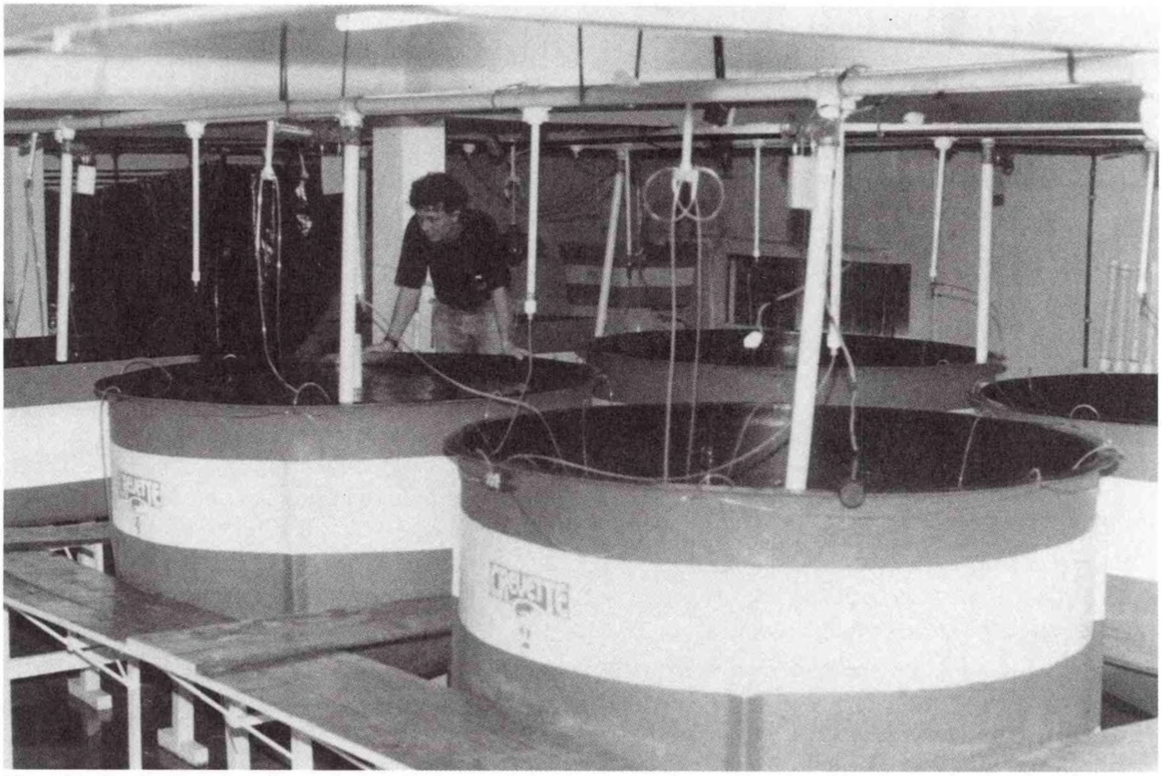


***Photo 15.*--Brazil. Larval rearing tanks at a freshwater shrimp hatchery. © Jomar Carvalho Filho, Panorama da Aqüicultura**

***Photo 16.*--Brazil. This hatchery has been modernized with a closed circulation saltwater and inverted photo period system. © Sergio Luiz de Sigueira Bueno, LPC/USP**

million pl per month (appendices H3-4).

Many Brazilian hatcheries are reportedly losing money. Hatcheries in 1990 reported sales averaging about $5.40 per 1,000 while wild pl was available for about $2.10.[180] The low cost of wild pl may be partially due to the presence of many undesirable species. Even so, most hatcheries would find it difficult to compete in the open market when wild pl is readily available. Most of the hatcheries, however, are operated as part of shrimp farms and losses are thus being subsidized by the company's overall operations. About 80 percent of marine shrimp pl is produced for internal company use and only the remainder is sold to other farms, mostly smaller operations.

Some observers believe that it may have been a mistake for Brazilian farmers to focus so heavily on hatcheries at this stage of their development. Even some companies focusing on indigenous species have attempted to open hatcheries. Given the small area of ponds and large indigenous stocks, it would seem that many farms could have supplied their pl needs by collecting in the wild.[181] Delaying heavy investments in hatcheries until farmers were generating income from growout operations would have assisted many struggling operations. Brazilian farmers may not have a choice, however, between constructing a hatchery industry or relying on pl collection from local estuaries. A considerable difference of opinion appears to exist among Brazilians on the availability of wild pl to support a shrimp culture industry. At least one observer believes that the industry will always have to rely heavily on hatcheries.[182] Unlike Ecuador, Brazilian shrimp farmers may not be able to obtain enough pl to sustain a large industry. While local fishermen can supplement hatchery pl, some observers believe that the hatcheries are a key element of the country's shrimp culture industry. Attempts to collect wild pl in Maranhao and other states have not been very successful. Little information appears to exist, however, on the quantities which could be collected, where collections could be conducted, species distribution, and seasonal variations.

Brazil is developing the *Artemia* industry needed to provide feed for the expanding hatchery industry. Local *Artemia* production began in 1977 and companies have had some success. The industry's growth was spurred by demand from the developing hatchery industry.[183] Brazil's 1988 *Artemia* production (both cysts and biomass) was 9 t, of which nearly 1 t was exported, mostly cysts. One of the companies involved is Artemisa Aquicultura.[184] Brazilian hatcheries initially had to import *Artemia*, but the country has now become a net exporter.[185] Several hatcheries continue, however, to report difficulties obtaining quality *Artemia* from Brazilian sources. The *Artemia* situation in Brazil is not entirely clear as some observers indicate that there is not a constant supply of readily available domestically produced cysts. Substantial quantities of Brazil's *Artemia* production have reportedly been committed for export, primarily to Spain.[186] One observer reports that for a variety of reasons (limited experience, inadequate investment, poor site selection, and other factors), Brazil has not fully developed its potential to harvest *Artemia*. As a result, Brazilian hatcheries continue to import *Artemia* when domestic product is unavailable. Brazilian researchers have access to the recently created Centro Brasileiro de Referencia em Artemia located in Natal.

XV. MARKETING

Marine species: Brazil has a significant domestic market for shrimp, unlike other Latin American countries which export most of their catch. As much as 80 percent of the Brazilian catch is consumed domestically. This is partially due to the difficulty in exporting non-*Penaeid* species, but also to a very strong local demand. Prices in Brazil can be higher than on the international market. This strong domestic market simplifies the distribution and marketing efforts since companies do not have to depend on the vagaries of the international market, or comply with often demanding foreign import rules. Farmers report receiving the highest prices when the domestic shrimp fishery is closed (March-May) and in the summer season (December-February). Some farmers have reported particularly good results when selling directly to consumers or restaurants in Rio de Janeiro, São Paulo, and Brasilia. The total demand in Brazil is unknown, but a variety of factors suggest that the potential market is much larger than is currently being supplied. One observer estimated that during 1988 the city of São Paulo alone had an approximate weekly deficit of 80 t of shrimp.[187] Shrimp catches have been relatively stable since 1986 (appendix C1), while the population has expanded. Unconfirmed reports of poor 1989 catches could mean supply shortages and, as a result, an increased domestic demand for cultured shrimp. Brazil's overall economic problems in the 1980s have restricted demand by limiting consumer purchasing

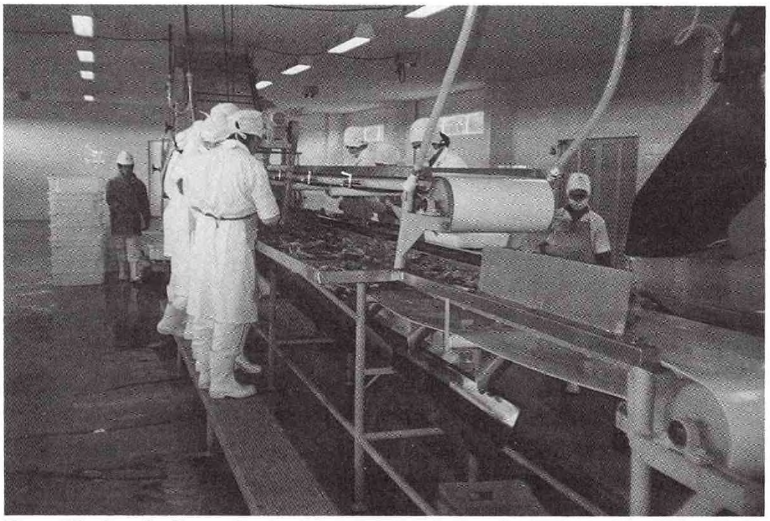


Photo 17.--Brazil. Processing freshwater shrimp in Brazil. © *Victor Wanderley, CACE*

power, but if and when the economy begins to expand again, a sizeable expansion of the domestic shrimp market is possible. Some farmers have reported success in entering the European market. There appears to be a good market for *P. subtilis* in Spain where it is reportedly highly prized by consumers because of its golden color after cooking. Farmers are reportedly selling small shrimp (10-12 grams) to the Spanish as whole product rather than just tails.[188] The success of such shipments is reportedly helping those farms which achieve good growth until the shrimp reach 12-14 grams. Farmers simply harvest when the shrimp stop growing.

Freshwater species: Most of Brazil's substantial harvest of freshwater shrimp is consumed in the domestic market. The harvest is generally sold locally, but some is also shipped to Rio de Janeiro and São Paulo. The Freshwater Shrimp Farmers Association of the State of Pernambuco has a retail shop in Recife where they sell directly to consumers. The Middle São Francisco River Valley Freshwater Shrimp Farmers Association have a similar distribution outlet in Petrolina (Pernambuco). One of the most modern processing plants is operated by Capiata Aquicultura. The company processes the harvest while the shrimp are still alive. They are washed, chill-killed, trimmed, sorted by size, packed, and IQF frozen (figure 9). The whole process reportedly takes only about 9 minutes. The frozen shrimp are mostly marketed locally, but the company would like to enter the export market and has made trial shipments to the United States (New York).[189] Growers report, however, considerable difficulty in expanding markets. Brazilian consumers seem to prefer marine species. One observer suggests that growers should place a greater emphasis on market promotion, suggesting that agreement be reached on a generic advertising campaign using a standard name. Freshwater shrimp are currently marketed using different names, confusing consumers. One useful step might be for growers to standardize harvesting sizes. Currently there is a great range of sizes available to consumers, but many growers focus on larger shrimp (greater than 50 gm). Growers could achieve much better yields, including multiple crops, if they harvested smaller sizes (30-35 gm). In addition, some reports suggest that smaller sizes taste better and are easier to cook.[190]

Culture still represents a small portion of the overall freshwater harvest, but this could change with the entry of larger companies backed with advanced foreign technology. Interest in farming is increasing as farmers report some success in expanding the domestic market. There are also limited export sales, primarily to Spain, Germany, and Italy. The key to the growth of the freshwater shrimp farming industry will be the market. Freshwater farming does not present as many technical problems as marine shrimp culture. Producing pl to stock ponds, for example, is a much simpler process than that needed for marine species. Brazilian farmers could rapidly expand production if stable markets could be found offering acceptable prices.

XVI. DISEASES

A. Marine Species

The current status of diseases in cultured *Penaeid* species are still not well studied in Brazil. Disease problems have been recognized, however, as they are having some impact on the industry's development. Disease control is a potentially important concern in Brazil and other countries which are developing commercial-scale industries. Brazil has no shrimp control or diagnostic facility. Pl and broodstock are traded within the country without inspection or sanitary certification. Exotic species have been imported without using quarantine facilities to hold the animals nor trained personnel to inspect them.[191] There are no Government regulations that could prevent the spread of diseases within the country. The absence of trained personnel and the diagnostic laboratories to support the developing shrimp industry is a serious constraint to the development of shrimp culture in Brazil. Local observers believe it is urgent that the industry give high priority to disease diagnosis and control. The absence of sanitary rules for importing exotic species is a common cause of disease outbreaks. Brazil is just at the beginning phase of the industry's development, but observers fear that the disastrous collapse reported in Taiwan (1989) and serious losses reported in Ecuador (1989-90) could also occur in Brazil.

Disease problems have primarily concernd hatchery managers. Some hatcheries have experienced disastrous runs with up to 100 percent mortalities. Growers are experiencing, however, some problems which have not yet been explained. Various farms have reported poor survival and disappointing yields which may have been associated with unidentified pathologies. Maricultura da Bahia, for example, discontinued *P. monodon* culture in 1987 due to poor growth in semi-intensive ponds which may have been due to a disease problem and the very high incidence of MBV infection.[192] Some farms in Bahia during early 1990 reportedly experienced disease outbreaks, probably as the result of importing *P. vannamei* pl from Ecuador. While important to consider, the disease problem at this stage of the industry's development should not be over stressed. While some disease outbreaks are appearing, the more important difficulties reported by farmers are probably due to poor farm management.[193]

Four different viruses and other pathogens have been reported in a variety of *Penaeid* hosts (appendix J). Much of the diagnostic work has been done by Dr. Donald Lightner at the University of Arizona, but the results have not yet been published. Several Brazilian research groups are addressing the disease problem, although relatively few institutions have staff with extensive backgrounds in shrimp pathology. The University of São Paulo and the Federal University of Bahia are working with *Baculovirus penaei*.[194] The Instituto de Pesca at the University of São Paulo is working in freshwater shrimp diseases.[195] The newly created Shrimp Diagnostic Laboratory at the University of São Paulo's Instituto de Biociencias will give Brazil its first research unit focusing specifically on shrimp diseases.

B. Freshwater Species

A disease of unknown etiology almost devastated the São Francisco Valley freshwater shrimp farms in 1988. As with marine species, many of the disease problems have been experienced in the hatcheries. Capiata Aquicultura reported a rickettsial disease problem at its freshwater shrimp hatchery, but has reportedly solved the problem.[196]

XVII. PROSPECTS

The future of the country's shrimp culture industry is uncertain, but there appears to be growing optimism among growers that conditions in Brazil will support a major shrimp culture industry. Firm assessments, however, are difficult to make at this time. Information from Brazil is scarce and often contradictory, making it difficult to assess the progress that the industry has made. Brazilian researchers themselves indicate difficulties in obtaining reliable data.

The Brazilian shrimp culture industry to date has reported uneven results. It is clear that many growers have encountered problems and some have gone out of business. Many of these early problems can probably be attributed to inexperience as would be typical of any industry in its initial phase, but ill-advised Government policies have compounded the problems. The better prepared and more committed growers currently entering the industry report improving results. Growers are gaining experience in culture techniques, familiarity with local conditions, and use of indigenous species. As a result, while the current harvests are relatively limited, considerable progress has already been achieved toward laying the foundation for an important shrimp aquaculture industry.

Some observers see a bright future for the Brazilian shrimp culture industry. Many are convinced that on balance, the climatic and other physical conditions in Brazil are appropriate for culturing shrimp. Tropical climate, low-cost land, inexpensive labor, and a developed agro-industrial base are all important advantages for Brazilian growers. Even some observers critical of the current efforts to develop the industry seem to concur that conditions in Brazil are appropriate for a major shrimp culture industry. The increasing attention being directed at shrimp culture by both investors and researchers bodes well for the future. A rising number of Brazilians have earned advanced degrees and the academic programs offered at Brazilian institutions are turning out increasing numbers of Brazilian technicians capable of engaging in a more sophisticated approach to the industry's problems. It is more and more common to find Brazilian farms with well-qualified technical advisors on their staff or under retainer. Given the increasing number and growing sophistication of individuals involved in the industry, it appears likely that Brazilian farmers could achieve considerable gains in the next few years.

Several problems, however, remain to be resolved by the industry.[197] Despite the progress in recent years, only limited **research** has been conducted to determine the best methods suited for Brazilian conditions and indigenous species. Hirono believes that this is one of the most pressing needs. Expanded research to determine the species and methods most appropriate for culture in Brazil could have a tremendous impact. Coelho and his associates believe that the absence of an **industry policy** toward research and training has impaired the industry's development. They also believe that the Government's failure to adopt an **environmental policy** which will protect the ecosystem needed by the industry will be an increasingly serious problem as the industry develops. **Poorly designed ponds**, especially those built in the early 1980s, continue to adversely affect yields. **Construction costs** are still well above those in many other countries. The shortage of **qualified technicians** continues to hamper operations at several farms. While feed companies have begun to produce **formulated feeds**, much work still remains to develop feeds and feeding strategies best suited to the species being used by Brazilian farmers. The failure of the country's **hatcheries** to supply adequate quantities of pl is another serious problem. Several observers are convinced that technical advances, such as increased hatchery production and development of feeds and handling techniques appropriate for **indigenous species**, could bring dramatic improvements in the industry's performance. Beyond the various technical problems, the shortage of financing will also impair the industry's development. Industry sources report that **financing** will be a very serious problem in the 1990s, especially in the near future given President Collor's stringent economic plan. Many companies are revising expansion plans as a result of the President's 1990 shock economic program. Growers report extremely high interest rates which virtually preclude expansion on new farm construction.[198]

International macroeconomic trends will also affect the development of Brazil's shrimp culture industry. World shrimp prices will have a major impact on future growth, especially if expanding world production adversely affects international prices. Shrimp culture industries are growing rapidly in China and several other Asian countries. The impact of these rapidly expanding harvests on the market is not yet fully known. Brazilian production costs are believed to be relatively high, and falling or even stagnant prices could strain many operations which are either not currently profitable or operating on tight margins. One local source reports that low shrimp prices has been a major factor limiting commitment by Brazilian investors. Other factors such as interest rates and oil prices will also have a major impact on the ability of farmers to expand their operations.

Some observers are concerned that Brazilian growers do not seem to be solving their problems as quickly as some other Latin American growers. This could be due to the special problems faced by Atlantic-coast growers. Shrimp farmers along the Pacific coast all had the advantage of access to wild pl of species which performed well, even in low-yielding extensive ponds. Both *P. vannamei* and *P. stylirostris* occur in all the Pacific coast Latin American countries from Mexico to Peru. Brazilian growers did not have this advantage. While individual Atlantic/Caribbean farms have achieved limited commercial success using hatchery-produced exotic species, no Latin American country has yet developed a large, successful shrimp culture industry based on Atlantic-coast species. Current indicators suggest that Brazilian growers are just now beginning to master growing techniques for indigenous species. Despite the optimism in some quarters, potential investors should consider the problems that growers continue to experience after more than 10 years of commercial operations. Such problems may reflect underlying physical and environmental conditions which may constrain the development of a major shrimp culture industry.

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ENDNOTES

SECTION I (Capture Fishery)

1. The other major Latin American fishery is conducted by Mexico, which has also experienced difficulties in developing a shrimp culture industry.

2. This is somewhat lower than estimates of 700-800 trawlers during the mid-1980s.

3. Precise 1989 shrimp catch data, however, is unavailable. The Brazilian Government (Fishing Activities Division) reports that Brazil's Statistical Data Bank has been deactivated and detailed shrimp catch data is unavailable. U.S. Embassy, Brasilia, April 24, 1990. One unconfirmed report suggests that the marine catch may have been as low as 35,000 tons.

4. Details on the *Penaeid* species involved are discussed in "Species." A glossary of Brazil's indigenous species is included as appendix B.

5. Available data is landings. High figures for Rio de Janeiro and São Paulo reflect where the shrimp was landed, which in some cases is different than where it was caught.

6. See "Species."

SECTION II (Conditions)

7. The Brazilian seasonal pattern differs somewhat from the Ecuadorean pattern. In Ecuador, cooler water temperatures are associated with the rainy season while in Brazil the reverse is true. Also Ecuadorean farmers experience much cooler water temperatures than in northern and northeastern Brazil. Hirono, *Survey Report on Brazilian Shrimp Farming Practice*, (CIRM/ABCC), 1988. See also appendix D1 and figure 3.

8. Ecuadorean farmers face much cooler water temperatures, especially during the rainy season when the effects of the cold Humboldt Current is most pronounced. Sea surface temperatures off southern Ecuador are usually 2-3° C below temperature levels off the comparable latitudes in northeastern Brazil. The temperature difference can be as high as 7-8° C (figure 3 and appendix D1). Climatic events in the Eastern Pacific can periodically intensify these differences and cause sea surface water temperatures off Ecuador to deviate substantially from normal levels for extended periods. Such events are sometimes referred to as "El Niños" and "Anti El Niños." The "Anti-El Niño" events have substantially reduced pond harvests in Ecuador. There is no comparable climatic event off Brazil which can cause such significant fluctuations in sea-surface temperatures.

9. Hirono, *Survey Report.*

10. Hirono, *Survey Report.*

11. See "Methods."

12. Hirono, *Survey Report.*

13. Sergio Zimmermann, Federal University of Rio Grande do Sul, personal communications, October 25, 1990. Also see "Research" and "Training."

14. Iracema Andrade Nascimento, Coordenadora, Mestrado em Produção Aquatica, Instituto de Biologia, UFBA, personal communication, May 14, 1990.

15. See "1970s" and "Early 1980s," and "Promotion."

16. Sergio Luiz de Siqueira Bueno, personal communications, October 4, 1990.

17. Aecio Moura da Silva, personal communications, May 14, 1990.

SECTION III (Potential Area)

18. U.S. Embassy, Brasilia, December 27, 1985.

19. Aecio Moura da Silva, *op. cit.* While the Brazil's shrimp culture industry is primarily based on tropical species in northeastern states, the potential in the south should not be dismissed. There are some marketing advantages to farming in the south which may at least partially offset higher operating costs. See "Southern Brazil." Much of the Chinese cultured harvest is *P. chinensis*, the most cold tolerant *Penaeid* species. A recent book (*The Culture of Cold-Tolerant Shrimp*) on farming cold-tolerant species is available from Dr. Kevan Main, Oceanic Institute, Makapuu Point, P.O. Box 25280, Honolulu, HI 96825. The book does not, however, address *P. paulensis* specifically.

20. Inter-Ministerial Commission on Marine Resources. The document available to the authors, but without a cover sheet with full bibliographical citation, cites a smaller area of about 100,000 ha, but more recent articles citing the Commission use the higher figure utilized in this report.

21. Mangrove areas themselves often do not make the best sites for shrimp ponds due to the high cost of clearance, inappropriate pH levels, and other reasons. Often the areas around mangroves, however, do make suitable sites.

22. Inter-Ministerial Commission on Marine Resources.

SECTION IV (Species)

23. U.S. Embassy, Brasilia, 1987. Most observers now believe the initial focus on *P. japonicus* was a mistake. L.A.O. Gomes, *Cultivo de crustaceos e molluscos*, Livraria Nobel: São Paulo, 1986.

24. Some observers question the availability of any large pl source that could supply Brazilian farmers, contending that commercial quantities of pl are available in only some favorable areas. Luis Antonio de O. Gomes, personal communications, October 27, 1990.

25. Bueno, personal communications, *op.cit.*

26. Or hatchery-produced pl of indigenous species when pl cannot be collected in local estuaries.

27. One observer insists that hatchery pl are not inherently more expensive, providing there is a sound hatchery industry (which he says is not the case in Brazil). He points to the low-tech approach in the Philippines, Taiwan, and Thailand as a possible alternative to the current Brazilian pattern of large, expensive maturation hatcheries. Gomes, personal communications, *op. cit.*

28. See "Feeds."

29. The cost of hiring highly skilled technicians, however, can be quite high, especially for specialties like shrimp culture. There are still relatively few Brazilians with extensive academic background and field experience, especially in areas such as hatchery maturation, nutrition, and pathology.

30. Bueno, personal communications, *op. cit.*

31. S.R. Coelho, "Aspectos tecnicos e econmicos da formlaçao de raçoes para camaroes," EMPARN, Natal (RN), 1986 and Coelho, "Estudo do nivel de proteina na raçao para juvenis de *Penaeus schmitti*," III Simposio Brasileiro Sobre Cultivo de Camarao, Joao Pessoa (PB), Brasil, 1989.

32. Luis Vinatea Arena, Laboratorio de Peneídeos de Barra da Lagoa, personal communications, September 3, 1991.

33. A recent assessment of the reproductive performance of *P. schmitti* is available in Bueno, "Maturation and Spawning of White Shrimp *Penaeus schmitti* Burkenroad, 1936, Under Large Scale Rearing Conditions," *Journal of the World Aquaculture Society*, Vol. 21, in press.

34. One researcher reports that *P. schmitti* and *P. vannamei* survival were similar as long as no major water quality problems occurred. In most instances where problems did occur, *P. vannamei* survived better. Bueno, personal communications, *op. cit.*

35. Nascimento, *op. cit.*

36. Dr. Sergio Luiz de Siqueira Bueno, currently with the Instituto de Biociencias, Universidade de Sao Paulo, is convinced that *P. schmitti* is the best all around choice for Brazilian farmers. Bueno, personal communications, *op. cit.*

37. Silvio R.C. Coelho, et. al., "El Cultivo de Camaron Marino en el Brasil," Joao Pessoa (PB), May 1990, p.21.

38. Andre Luiz de M. Nogueira, personal communications, August 1990. Nogueira is currently working on *P. schmitti* for SOCIL. He has previously worked on an FAO project assessing shrimp culture feeding methods and pond management in Brazil.

39. Bueno, personal communications, *op. cit.*

40. Some reports will list *P. aztecus* as a species being reared in hatcheries and tested in trial runs. This reflects the tendency of some growers to use *P. aztecus* as a shortened form of *P. aztecus subtilis*. In most instances the authors are probably referring to what is now generally recognized as *P. subtilis*.

41. Gomes, personal communications, *op. cit.*

42. Marcos Alberto Marchiori, Shrimp Culture Laboratory, Rio Grande University, personal communications, May 28, 1990.

43. Vinatea, *op. cit.*

44. Bueno, personal communications, *op. cit.*

45. Moura da Silva, *op. cit.*

46. De Souza, *op. cit.* Even so, actual harvests of *P. subtilis* may be larger.

47. See "Marine Species."

48. PESCON is owned by Maricultura de Bahia.

49. The use of exotics by only a small number of farms is confirmed by the ABCC (appendix G6) and Dr. Motonaga Iwai, Instituto Oceanografico, Universidade de São Paulo, personal communications, August 21, 1990. The exact number of farms and species distribution, however, varies from source to source.

50. Possibly Baculovirus penaei-BP.

51. Jorge Requena, Acqua-Biotica, personal communications, November 1988.

52. Inter-Ministerial Commission, *op. cit.* and Itamar de Paiva Rocha, MCR Aquacultura Ltda., personal communications, February 8, 1990. Other observers also stress that there continues to be substantial interest in *P. vannamei*. Gomes, personal communications, *op. cit.*

53. SUDEPE gave preference to loan requests for projects focusing on *P. japonicus*. Bueno, personal communications, *op. cit.*

54. Cornelius R. Mock, "Report on Penaeid Shrimp Culture Consultation and Visit, Brazil, South America, January 24-February 7, 1982" and "Trip Report on Penaeid Shrimp Culture Consultations and Visits, Brazil, Venezuela, and Panama," May 2, 1983.

55. The various indigenous species of freshwater shrimp are listed in appendix B.

56. Gomes, personal communications, *op. cit.*

57. Rocha, *op. cit.*

58. At least one local observer is concerned about the freshwater shrimp projects in the São Francisco River valley. This is an intensively farmed area and seasonal insecticide spraying affects the water runoffs into the river. This may not have been considered by local investors. Gomes, personal communications, *op. cit.*

59. Moura da Silva, *op. cit.*

60. Zimmermann, personal communications, *op. cit.*

61. See "Capiata Aquicultura."

SECTION V (Harvests)

62. The primary sources are indicated in appendix E2.

63. Jose Roberto M. Cunna da Silva and Andre Luiz de M. Nogueira, "Perfil da Alimentção de Camarões Marinhos e de Agua Doce do Brasil," FAO/Governnment of Italy Cooperative Project (GCP/RLA/075/ITA), August 1988.

64. Cornelius Mock prepared a detailed report on one such operation, CONVESCO. Cornelius Mock, Trip report on *Penaeid* Shrimp Consultations and Visits, Brazil, Venezuela, and Panama," memorandum attachment, May 2, 1983.

65. Philip Scott, "Shrimp Farming in Brazil," *Fish Farming International* May, 1990, p.18.

66. Gomes, personal communications, *op. cit.*

67. Some observers report higher harvest estimates. The Branch has received, for example, 1990 projections as high as 3,000 tons. The Branch believes that the more conservative ABCC estimate is probably the most reliable. It should be stressed, however, that industry data can sometimes be compromised by the tendency of farmers to release overly optimistic reports on results at their farms.

68. Coelho, "El Cultivo ...".

69. The results achieved in Brazil, however, should be put in perspective. While results have been limited, the resources and energy of early efforts were also minor, especially in comparison to the major efforts organized in several Southeast Asian countries.

70. FAO provides slightly higher harvest estimates of 1,000 t for the 1986-88 period.

71. Dr. Wagner Cotroni Valenti, FCAUJ Aquaculture Center/UNESP, personal communications, June 10, 1991.

72. For details on one Israeli project, see Ziva Ra'anam, Gilad Issar, Antonio Frei, and Rilton Rodrigues, "Effect of Winter on Growth of the Prawn *Macrobrachium Rosenbergii* in a Commercial Farm in the Tropics," *The Israeli Journal of Aquaculture--Bamidgeh*, Volume 42, No. 1, 22-30 and "Em Alagoas, a maior criação de camarão," *Diregante Rural*, September 1989, 35-36.

SECTION VI (Legal Framework)

73. See "Promotion."

74. Law 95792, March 7, 1988, on which the shrimp culture development program is based, is particularly important. Daniel D. Benetti, "A Hypothetical Project for a 100 Tons/Year Shrimp Farm in Northeastern Brazil," *Proceedings III Brazilian Shrimp Farming Congress*, J. Pessoa, PB, October 16-20, 1989.

75. See "Diseases."

SECTION VII (Government Assistance)

76. See "Potential Area."

77. Gomes, personal communications, *op. cit.*

78. One observer warns that very few academic papers have been published. Many of the academic groups are poorly funded and have had only limited resources available for serious research. Much of the most valuable research has been conducted by the growers themselves. Gomes, personal communications, *op. cit.*

79. One report suggests that CEPLAC has conducted less than 10 trials since the hatchery opened in 1983.

80. Dr. Motonaga Iwai, personal communications, August 21, 1990.

81. SUDEPE was formerly an appendage of the Ministry of Agriculture. It was incorporated into the Brazilian Institute for the Environment (IBAMA) during 1988. President Collor has directed that IBAMA report directly to his office as a result of the growing importance of environmental issues.

82. BID is the Portuguese/Spanish acronym for the Inter-American Development Bank (IDB).

83. Gomes, personal communications, *op. cit.*

84. U.S. Embassy, 1986; 1988. Data on Brazilian ponds vary substantially. One observer (Iwai, personal communications, *op. cit.*) reports that the maximum in 1986 could not have exceed 2,500 hectares. Discrepancies among sources in some cases reflect the lack of official data and the difficulty individuals face in collecting information in such a large country. In other instances it reflects differing reporting guidelines, such as confusing planned construction with finished ponds (both active and inactive). Most observers agree that only 2,000-2,500 ponds were in use during 1986, although the area actually constructed may have been larger. Various other sources indicate about the same level of activity until 1988, when new farms increased the active pond area to 3,500 ha (appendix E2). Unconfirmed reports suggest that many of the earlier farms were poorly designed. Data on 1986 pond area appeared in *Aquaculture Digest*, 1987 issues. Other 1986 estimates were made by Marcos Rogerio Camara (UPPC/EMPARN) and Carlos Lamartine Torres Mello (SUDEPE), unpublished data, 1988.

85. Rocha, *op. cit.*

86. Iwai, personal communications, *op. cit.*

87. Peter Shayne, "Aquaculture: Brazil & Other Latin American Countries," *Shrimp World Market Conference: Proceedings*, November 29 to December 2, 1984. Brazilian construction costs apparently averaged between $15,000-20,000 per ha, about 250 percent above SUDEPE projections and as much as four times the cost of Ecuadorean construction. Coelho, "El Cultivo ..."

88. Brazil has a substantial aquaculture industry, but growers have focused primarily on carp, tilapia, and a variety of indigenous finfish. Quite a large number of artisanal fishermen are involved in fishing species stocked in reservoirs. "La Acuicultura en Brasil," *La Acuicultura en America Latina*, Vol. III, 128-136 in *Informes de Pesca*, No. 159, 1974 and Aquaculture Development and Coordination Programme, *A Regional Survey of the Aquaculture Sector in Latin America*, ADCP/REP/89/39, 1989. As a result there were relatively few Brazilians knowledgeable about shrimp culture available to assist the industry during the early stage of development.

89. Moura da Silva, *op. cit.*

90. Scott, *op. cit.*

91. Two especially serious limitations would be the limited supply of pl and formulated feed, but many other problems would make it difficult to rapidly develop the industry. Iwai. *op. cit.*

89. Chiu Liao and Luiz Antonio de Oliveira Gomes, "Experiences from the Prawn Culture Industry of Taiwan and Relevant Considerations for the Development of the Industry in Brazil," paper presented at the Third Brazilian Shrimp Farming Congress, October 15-20, 1989, João Pessoa, PB.

90. Gomes, personal communications, *op. cit.*

SECTION VIII (Methods)

91. Cunna da Silva and Nogueira, *op. cit.*

92. Hirono, *Survey Report*.

93. *Ibid.*

94. *Ibid.*

95. Iwai, *op. cit.*

96. Several Brazilian authors provide more detailed breakdowns, distinguishing between semi-extensive and semi-intensive. Such distinctions are often difficult to make as farmers employ vastly different farm management strategies. Some basic guidelines are listed in appendix W. The best indicator of the situation at individual ponds is probably the yield achieved (appendices F3, G2, G5, and G6). Most Brazilian farms are probably best described as either extensive or primitive semi-intensive (semi-extensive) farms.

97. Itamar da Paiva Rocha, MCR Aquacultura Ltda., personal communications, February 1990. Another source stresses that many of these farms have begun to employ some semi-intensive methods such as supplemental feeding, but have not modified their existing large, extensive ponds.

98. Only two farms reportedly employed stocking densities above 5 pl per square meter. Hirono, *Survey Report*.

99. Iwai, *op. cit.*

100. Hirono, *Survey Report*.

101. Cotroni, *op. cit.*

102. For details of one experiment with batch culture see Ra'anan, *et.al.*, *op. cit.*

103. Price at hatchery without packaging or transportation. Full price to many farmers might be as much as $28 per 1,000 postlarvae. Prices have reportedly been relatively stable since 1988. Zimmermann, personal communications, *op. cit.* Other observers have reported somewhat lower pl prices, perhaps reflecting regional differences within Brazil.

104. Some reports suggest an Israeli company is also involved in Sergipe, but these references may be confusing the location with neighboring Alagoas. Israeli technology is ideally suited to large areas of Brazil which have arid climates. Israeli aquaculture technology was developed based on constraints of water limitation. The Israelis have done considerable work to develop methods for using ground water available in some desert areas for aquaculture. Hence, freshwater aquaculture is integrated with irrigation. Water is first used for aquaculture and subsequently for irrigation. The cost of water management is therefore shared by the two agricultural efforts. In arid climates, rain water can be collected in reservoirs in which fish are raised. As the water is gradually withdrawn for irrigation throughout the dry season, fish are harvested accordingly to reduce the biomass . Cohen, *op. cit.*

105. "Em Alagoas..." *op. cit.*

106. Ra'anan *et.al.*, *op. cit.*

107. Zimmermann, personal communications, *op. cit.* Zimmermann is the company's nutritional advisor.

108. Ideadeco is marketing the technology of Aquaculture Production Technology (Israel) Ltd (APT). The APT Research and Development Division is affiliated with the Hebrew University of Jerusalem.

109. U.S. Embassy, Quito, July 6, 1990.

110. Cohen, *op. cit.*

111. One observer is also impressed with the technology developed in Taiwan. Gomes, personal communications, *op. cit.* *See also* Liao and Gomes, *op. cit.*

SECTION IX (Feeds)

112. Cunna da Silva and Nogueira, *op. cit.*

113. *Ibid.*

114. Luigi Petti, Maricultura de Bahia, personal communications, August 21, 1991.

115. For details on feeding systems see tables 12 and 13. *Ibid.*

116. The research is being conducted jointly with the Life Sciences Institute of the Hebrew University of Jerusalem and funded by CNPq and the Israeli APT company. The German-Israel Corporation for Research in Agriculture (GIORA) also participates in the project. Details have been nicely summarized in an unpublished paper, Sergio Zimmermann, "Nutritional Studies of Growth and Reproduction in Decapod Crustaceans for Industrial and Agricultural Application," 1990.

117. Nascimento, *op. cit.*

118. Petti, *op. cit.*

119. This might partially explain the lower yields achieved with *P. schmitti* and other species.

120. Bueno, personal communications, *op. cit.*

121. Scott, *op. cit.*

122. One observer feels that farmers may not be fairly assessing the available feed. Few farmers have carefully controlled feeding systems which would allow them to assess the effectiveness of the feed. Basic information on the nutrients already in the water, pond conditions, and the physiology of the shrimp species are not being collected by the farmers. Hirono believes that such data should be collected and used in establishing a feeding system before criticizing feed manufacturers, who could play a very important role in the industry's development. Hirono, *Survey Report*.

123. FAO, *Yearbook of Fishery Statistics*, 1988.

SECTION X (Yields)

124. Farmers sometimes reported harvests of only one-third of those anticipated. Iwai, *op. cit.*

125. The first report includes detailed statistical analysis of farm results based on a variety of different variables. Hirono, *Survey Report*. The second report includes detailed statistical appendicies on both farm and hatchery operations. Cunna da Silva and Nogueira, *op. cit.*

126. Great caution should be taken in evaluating available yield data. Farmers tend to exaggerate yields. This is often not a blatant effort to falsify data, but a quite natural tendency to view one's own operation in the most favorable light. Often growers will select their best harvest and then extrapolate annual harvest data which can vary substantially from actual results. This tendency is particularly troublesome given the reliance of this report on industry data.

127. Getulio de Souza Neiva, Chief DEPAQ/IBAMA, personal communication, June 13, 1990.

128. That farm was Maricultura da Bahia which reported annual yields of 1.2 t per hectare.

129. Moura da Silva, *op. cit.*

130. See footnote 123.

131. Hirono's report includes detailed statistical computations on yield data, including an analysis of stocking density, survival, length of growout, harvest size, stocking size, and pond size. The 1988 number is based on only a small number of farms, but the declining yield trend was also noted in 1987 when a substantial number of farms reported. Hirono, *Survey Report*.

132. While still reporting a wide range of yields, these observers found five farms with annual yields of 1.0 t per ha or more. Cunnna da Silva and Nogueira, *op. cit., table 1.*

133. Iwai, *op. cit.*

134. Coelho, "El Cultivo...".

135. Brazilian growers will have relatively low yields as long as they use extensive methods. The low average yield in Ecuador also reflects the large number of extensive farms. Countries like Honduras and Panama tend to have higher yields because of the greater importance of semi-intensive farms.

136. Paiva Rocha, *op. cit.*

137. Moura da Silva, *op. cit.*

138. Paiva Rocha, *op cit.* and Paiva Rocha, personal communications June 15, 1990 and De Souza, *op. cit.* The upper limit of the range (4.0 t per ha) seems extremely high and cannot be verified at this time.

139. Souza, *op. cit.* Souza adds that one group achieved substantially higher yields (2.0-2.3 t per ha) by conducting selective harvests and constantly adding additional pl every month or two.

140. Gomes, personal communications, *op. cit.*

141. Alexandre Bacellar Raupp and Sergio Zimmermann, Faculdade de Agronomia, Universidade Federal de Rio Grande do Sul, "The Production of Freshwater Prawn, *Macrobrachium rosenbergii* (de Man), in Southern Brazilian Ponds, Under Different Initial Weight and Densities, *III Simposio Brasileiro Sobre Cultivo de Camarão, October 1989.* Zimmermann reports that farmers in the southern-most state of Rio Grande do Sul achieved an annual yield of only about 0.4 t per ha in 1989, but this was because most were only part-time operators using basic technology. He reports annual yields at his farm of 1.3 tons. Zimmermann, personal communications, *op. cit.*

142. "Em Alagoas..." *op. cit.* and Zimmermann, personal communications, *op. cit.*

143. Ra'anan, *et. al., op. cit.*

SECTION XI (Production Costs)

144. Moura da Silva, *op. cit.*

145. Controni, *op. cit.*

146. De Souza, *op. cit.* Other observers still question if any significant number of growers have achieved profitable commercial operations. One observer, for example, reports that he is unaware of any farm that is reporting substantial profits. Gomes, personal communications, *op. cit.*

147. Gomes, personal communications, *op. cit.*

148. De Souza, op. cit.

149. Petti, *op. cit.*

150. Benetti, *op. cit.*

SECTION XII (Companies)

151. Various reports suggested 515-550 hectares.

152. Petti, *op. cit.*

153. EMPARN's Shrimp Mariculture Project originally introduced the species in 1981/82.

154. Several local observers believe that the decision not to select an indigenous species was a serious mistake.

155. Ben Ribelin, personal communications, October 10, 1989, as cited in item 15.1.23, *World Shrimp Farming*, January 1990.

156. Petti, *op. cit.*

157. The following farms are primarily marine shrimp operations. Details on freshwater farms are available in Cunna da Silva and Nogueira, *op. cit.*

158. The hatchery is known as Aquatec Ltd.

159. Dan Cohen, Aquaculture Production Technology, personal communications, October 16, 1990. Details on the Capiata Aquicultura were presented by Cohen at the June 1990 meeting of the World Aquaculture Society, *Abstracts: World Aquaculture 90* (T22.4), June 10-14, 1990. For a description of the hatchery see "Hatcheries," page 24.

160. Ra'anan, *et. al., op. cit.*

161. A. Sagi, E. Snir, and D. Cohen, the Hebrew University and Aquaculture Production Technology (Israel) Ltd., "Maturation, growth and reproduction of sex reversed *Macrobrachium*," *(T18.5) Abstract: World Aquaculture 90, op. cit.* Cohen reports that males grow faster and to larger sizes. Stocking only males can increase yields up to 70 percent. Cohen, personal communications, December 12, 1990.

162. Petti, *op. cit.*

163. For details see "Marine Species."

SECTION XIII (Regions)

164. Details on the area in each state best suited for farming shrimp are available in the Inter-Ministerial Commission, *op. cit.*

165. Requena, personal communications, May 14, 1990.

166. Gomes, personal communications, *op. cit.*

167. One report suggests that this is a low estimate and as much as 1,600 ha of ponds may be in operation.

168. The author is using primarily appendix G9 for these state overviews. The reader should note, however, that appendix E3 and F3 also provide estimated state data. In addition, several appendices have estimates for individual companies. Given the discrepancies between the various sources, the estimates involved should be considered to be approximate indications of the level of activity in each state.

169. Yields at these farms generally vary from 1.0-1.5 t per hectare. Catroni, *op. cit.*

170. Zimmermann, personal communications, *op. cit.*

171. The University's project is centered at Pattos Lagoon, the largest nursery area in southern Brazil. Catches in the lagoon, however, have varied widely in recent years (500-8,000 t per year). The first release of pl from the University's new Shrimp Culture Laboratory is scheduled for October 1990. The laboratory has four maturation tanks and eight larviculture tanks. Marchiori, *op. cit.*

SECTION XIV (Hatcheries)

172. While this has been the case in Ecuador, not all observers agree. Gomes contends, for example, that not all hatchery pl are more expensive or give lower yields. He maintains that hatchery pl are more predictable because they are more uniform in size, age, and species. He add that costs vary widely depending on the hatchery industry situation. He insists that the quality of hatchery pl has improved with the recent introduction of new larval nutritional concepts. Gomes, personal communications, *op. cit.*

173. "Equipment Through the Back Door," *Fish Farming international*, February 1989.

174. Coelho, "El Cultivo," p.17.

175. Inter-Ministerial Commission, *op. cit.*

176. The most recent year for which data is available.

177. The review is based on experiences at Maricultura de Bahia, S.A. Sergio Luiz de Siqueira Bueno, *Tecnicas, procedimentos e manejos para a produção de pos-larvas de camarões penedideos*, Maricultura de Bahia/CIRM, 1989.

178. Capiata uses the pl for its own growout operations and for sale to other growers. About 0.3-0.6 million are sold to other growers monthly. Cohen, *op. cit.*

179. Rocha *op. cit.*

180. Souza, *op. cit.*

181. Hirono, *Survey Report*.

182. Bueno, personal communications, *op. cit.*

183. Item 11.2.41., *Aquaculture Digest*, February 1986.

184. Luis Vinatea Arana, Departamento de Aquicultura, Universidade Federal do Santa Catarina, "Produccion Comercial de *Artemia sp.* en la Salina 'Cristo Redentor', Acarau-CE, Brasil, *III Simposio, op. cit.*

185. Inter-Ministerial Commission, *op. cit.*

186. Gomes, personal communications, *op. cit.*

SECTION XV (Marketing)

187. Moura da Silva, *op. cit.*

188. Scott, *op. cit.*

189. Cohen, *op. cit.*

190. Gomes, personal communications, *op. cit.*

SECTION XVI (Diseases)

191. Bueno, "A Collaboration Programme Between the United States and Brazil for the Development of Human Resources and Technical Assistance on Shrimp Pathology," July 1990. Dr. Bueno's document was prepared to initiate cooperative work between U.S. and Brazilian scientists, specifically the University of Arizona and the Universidale de São Paulo. Dr. Bueno is seeking financial aid from Brazils' CNPq and the U.S. National Science Foundation.

192. Bueno, personal communications, *op. cit.*

193. Hirono, *Survey Report*.

194. Bueno, *et. al.* "Registros de Infecçães Causadas por *Baculovirus penaei*em Especies Nativas de Camarões Marinhos no Brasil, *III Simposio, op. cit.*

195. Julio Vicente Lombardi and Vera Lucia Lobão, Instituto de Pesca, Universidade de São Paulo, "Enfermidades e Fatores Condicionantes de Mortalidade na Larvicultura de Camarões de Gênero *Macrobrachium*" and "Doenças e Demais Fatores Causadores de Mortalidade em Camarões Jovens e Adultos Pertencentes ao Gênero *Macrobrachium*," in *III Simposio, op. cit.*

196. A description of the problem and details on treatment is available in Dan Cohen and G. Issar, "Rickettsial Disease of *Macrobrachium rosenbergii* Larvae" *Abstracts: World Aquaculture 90*, (T18.5) World Aquaculture Society: June 10-14, 1990, Halifax Canada.

SECTION XVII (Prospects)

197. Three good assessments of the Brazilian situation exist. Yosuke Hirono, a long-time participant in the Ecuadorean shrimp culture industry. Yosuke Hirono, "Survey Report." Another good assessment was prepared by Brazilian experts Silvio R.C. Coelho, Itamar da Paiva Rocha, Lenin E. Paredas in 1990. Coelho, "El Cultivo ...." The other is Cunna da Silva and Nogueira, "Perfil da ...."

198. A 1991 report suggests annual interest rates at 30 percent per year plus an inflation adjustment. Petti, *op. cit.*

APPENDICES

Appendix A.--Brazil. Addresses

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Appendix B.--Brazil. Marine shrimp species

Species		
Scientific	English*	Portuguese
Marine		
Artemesia longinaris	Argentine stiletto	Serrinha/Argentina/ferrinho/barba branca
Exhippolysmata o.	Cock	Espinho/vermelho/ovado
Penaeus		
brasiliensis	Red/pink spotted	Rosa/lixo
notialis	Southern pink	Rosa
paulensis	São Paulo	Rosa
schmitti	Southern white	Legitimo/verdadeiro/branco/lixo/vila franca/caboclo
subtilis**	Southern brown	Lixo/vermelho/branco/Cabeçudo
Pleoticus muelleri	Argentine red	Santana/vermelho/ferro/barbado
Sicyonia dorsalis	Rock shrimp	Da pedra/muido
Trachypenaeus constrictus	Roughneck	Branco/ferrinho
Xiphopenaeus kroyeri	Atlantic seabob	Sete barbas/chifrudo
Unknown	Unknown	Barba russa
Freshwater		
Macrobrachium	River prawn	
acanthurus	Cinnamon	Del rio/canela
amazonicum	Amazon	Sossego
carcinus	Painted	Pitu/potipema/del rio
olfersii	Buchura	Aratanha

* FAO terms
** Formerly considered to be a subspecies of P. aztecus. Previously this species was not distinguished from P. brasiliensis. Some Brazilian authors mistakenly refer to P. aztecus instead of P. subtilis.
Source: FAO. "Shrimps and Prawns of the World" FAO Species Catalogue, Vol. I, Rome, 1980.

Appendix C1.--Brazil. Wild and cultured shrimp harvest, by species, 1980-89

Year	Species: Fresh Water	Species: Marine	Total
	1,000 metric tons		
1980	9.9	48.0	57.9
1981	10.1	46.3	56.5
1982	10.4	52.1	62.5
1983	10.5	49.2	59.7
1984	8.8	58.6	67.5
1985	10.2	67.5	77.7
1986	10.3	55.4	65.8
1987	10.3F	54.6	67.9
1988	10.3F	57.8	67.8
1989	NA	35.0*	NA

F - FAO estimate
NA - Not available
* Unconfirmed Brazilian report.
Source: FAO. Yearbook of Fishery Statistics, various years.

Appendix C2.--Brazil. Shrimp catch, 1987

Region/state	Marine*						Freshwater	Total
	White	Pink	Unknown	Seabob	Red	B.Rusa		
			1,000 Metric tons					
North								
Amapa	-	1.0	-**	-	-	-	-	1.0
Para	-	1.0	3.5	-	-	-	4.0	8.5
Maranhao	0.8	1.2	4.3	1.4	-	-	0.3	7.9
Northeast								
Piaui	-	-	0.6	-	-	-	0.1	0.6
Ceara	Negl	Negl	2.1	Negl	-	-	1.4	3.5
Rio G. do Norte	Negl	-	0.6	-	-	-	0.4	1.1
Paraiba	-	-	0.1	-	-	-	0.4	0.5
Pernambuco	0.1	-	0.1	Negl	-	-	Negl	0.3
Alagoas	0.1	-	1.1	0.8	-	-	0.1	2.1
Sergipe	0.1	0.1	1.1	0.4	-	-	0.1	1.8
Bahia	0.8	-	4.2	0.1	-	-	0.7	5.7
South								
Espirito Santo	0.1	0.1	Negl	1.5	-	-	Negl	1.7
Rio de Janeiro	0.1	0.5	1.3	1.4	-	4.2	0.1	7.4
São Paulo	0.2	0.9	Negl	5.3	1.0	-	-	7.5
Parana	0.1	-	-	0.4	-	-	-	0.5
Santa Catarina	0.2	0.7	0.7	3.9	0.8	0.1	Negl	6.5
Rio G. do Sul	-	-	5.9	0.3	-	-	-	6.2
Total	2.5	5.4	26.9***	15.4	1.9	4.4	8.9***	65.4***

Note: The above does not include cultured harvests. Obtaining data on the Brazilian shrimp fishery has proven extremely difficult. Discrepancies with appendix C1 are unexplained.
difficult to obtain. The above data gives some idea on the relative importance of each region and state. The data should be viewed, however, with considerable caution as other available data gives widely varied quantities.
* Source does not indicate the species of the major category. White probably refers to Penaeus schmitti, pink is P. brasiliensis and paulensis. Red is Pleoticus muelleri. Barba rusa is unknown.
** Mistake in source makes it unclear as to the species taken in Amapa.
*** Discrepancy with appendix C1 is unexplained. Data in source does not add.
Source: IBGE.

Appendix D1.--Latin America. Sea surface temperatures, 1989-90

Year/ Month	Pacific: Southern Ecuador	Pacific: Northern Peru	Atlantic: Northeast Brazil	Atlantic: Southern Brazil
	Degrees Celsius			
1989				
January	23	21	27	23-25
February	24	23	27	24-26
March	25	23	28	22-26
April	25	23	26	20-25
May	21	19	28-29	18-24
June	24	20	27	15-18
July	NA	NA	NA	NA
August	23	19	26-27	15-22
September	22	18	27	14-20
October	23	19	27	16-21
November	22	19	27-28	19-22
December	25	21	27	21-24
1990				
January	25	22	27	21-24
February	25	22	27	24-26
March	26	23	27	24-26
April	24	21	27	22-25
May	25	22	28	19-24
June	24	21	27	15-23
July	24	20	27	15-22
August	25	20	25-27	14-21
September	25	21	25-27	12-18
October	22	19	26-27	18-22
November	22	20	26-27	18-23
December				

Note: Temperatures are approximations based on visual approximations from map graphics.
NA - Not available
Source: Climate Analysis Center. National Weather Service. National Oceanic and Atmospheric Administration. TOGA Analysis.

Appendix D2.--Brazil. Water temperatures

State	Minimum	Average Minimum	Average Maximum	Maximum
		Degrees Celsius		
Maranhao	27	28 (M)		33
Piaui	25		30	32
Ceara	25			33
Rio G. do Norte	26			32
Bahia	21	25		32-33
Santa Catarina	11			31

M - Morning
Source: Yosuke Hirono, Survey Report: Situation on Brazilian Shrimp Farming Practice, April 1988.

Appendix E1.--Brazil. Areas suitable for marine shrimp culture in northern and northeastern Brazil

Region/ state	Area		
	Mangroves	Targeted*	Identified**
	1,000 Hectares		
North			
Para	214.7	7.1	0.1
Maranhao	515.9	38.0	0.9
Northeast			
Piaui	4.4	0.7	1.5
Ceara	22.6	6.4	0.6
Rio G. do Norte	6.7	6.7	1.6
Paraiba	10.1	0.6	0.2
Pernambuco	7.3	NA	NA
Alagoas	3.6	NA	NA
Sergipe	11.0	0.8	0.2
Bahia	32.6	11.2	2.3
Total	828.8	81.7	7.6

* Area with suitable sites which the Government is promoting development as part of a 5-year plan.
** Includes areas already constructed (operating and closed farms), under construction, or planned
Source: Comision Interministerial. Ministerio da Agricultura, 1989.

Appendix E2.--Brazil. Marine and freshwater shrimp culture, pond area and harvests, 1980-90.

Year	Area		Pond harvest	
	Marine	Freshwater	Marine	Freshwater
	1,000 Hectares		1,000 Metric Tons	
1980	NA	NA	-	NA
1981	NA	NA	-	NA
1982	NA	NA	Negl	NA
1983	NA	NA	0.1	NA
1984	NA	NA	0.2	NA
1985	2.3	NA	0.4	NA♦
1986	2.3	NA	0.5	NA♦
1987	2.8&	NA	0.5	0.5♦
1988	3.5	NA	0.8	NA♦
1989	3.3#	0.3##	1.3*	0.7
1990	3.8###	NA	1.7P**	NA

♦ FAO estimates a harvest of from 900-1,000 tons.
& See appendix G2 for details. Active ponds probably did not exceed 2,000 ha (appendix G4).
\# Another source (Philip Scott) estimates 3,000 were active with another 1,800 ha under construction.
\## This appears to be a low estimate based on the actual harvest which if yield estimates of about 1.5 t per hectare are correct, suggest a pond area of nearly 500 hectares.
\### Estimates vary widely. Some observers (Itamar da Paiva Rocha and Motonaga Iwai) believe that there are probably no more than 2,500 ha of ponds, but they may be referring to active ponds. Other sources suggest 2,200 ha of active ponds (appendix G9).
* Estimates vary from 900-2,500 tons. Bob Rosenberry confirms the mid-range figure with a 1989 estimate of 1,500 tons. World Shrimp Farming, 1989.
** Projections have been made as high as 3,000 tons. One observer (Iwai) believes the harvest may actually decline to only 1,000 tons.
Note: No Government agency has compiled definite data on shrimp culture harvests or pond area. The numbers presented here are based on the estimates of various industry groups and observers.
Sources: NMFS estimates (1980-84 marine harvest estimate and 1985-86 pond area estimates); FAO. "Aquaculture Production (1985-88)", FAO Fisheries Circular No. 815, Revision 2, June 1990 (1985-88 marine harvest data); MCR-Aquacultura and Associaço Brasileira dos Criadores de Camarão (1989-90 marine harvest data and projection); U.S. Embassy, Brasilia, 1986 (1986 pond area estimate); unpublished survey conducted by Marcos Camara of EMPARN and Carlos Torres Mello of SUDEPE (estimates of 1987 pond area and harvest data); various reports of industry observers published in "Aquaculture Digest" (estimates of 1988 pond area and harvests); "World Shrimp Farming 1989" (estimates of 1989 pond area and harvests), and personal communications from Itamar da Paiva Rocha (estimates of 1989 pond area and harvest); The Brazilian Association of Shrimp Producers (1990 pond area estimate); and Getulio de Souza Neiva, Chief, DEPAQ/IBAMA, June 13, 1990 (freshwater pond area estimate).

Appendix E3.--Brazil. Shrimp farm pond area, 1990

State	Ponds Built	Ponds Planned	Total
	Hectares		
North			
Marnhao	300	611	911
Northeast			
Bahia	1,450	714	2,164
Ceara	490	135	625
Paraiba	172	150	322
Piaui	686	860	1,546
Rio Grande do Norte	497	1,255	1,752
South			
Santa Catarina	256	200	456
Total	3,851	3,975*	7,776

* Small mathematical discrepancy in source.
Source: Silvio R.C. Coelho, Itamar de Paiva Rocha, and Lenin E. Paredes. "El Cultivo de Camaron Marino en el Brasil," Joao Pessoa (PB), May 1990.

Appendix F1.--Brazil. Marine shrimp harvest, wild and pond culture, 1980-90.

Year	Harvest Wild	Harvest Pond	Total	Proportion Cultured
	1,000 Metric Tons			Percent
1980	48.0	-	48.0	-
1981	46.3	-	46.3	-
1982	52.1	Negl	52.1	Negl
1983	49.1	0.1E	49.2	Negl
1984	58.4	0.2E	58.6	Negl
1985	67.1	0.4E	67.5	1
1986	54.9	0.5E	55.4	1
1987	54.1	0.5E	54.6	1
1988	57.0	0.8E	57.8	1
1989	NA**	1.3E	NA	NA
1990	NA	1.7P	NA	NA

* Primarily Penaeid species, but substantial catches of seabobs and other low-value species (appendix B)).
** Unconfirmed reports from Brazil suggest that the marine catch declined sharply in 1989.
E-NMFS estimates
Source: Appendix E2 (pond harvest) and FAO. Yearbook of Fishery Statistics, 1987 (total shrimp harvest).

Appendix F2.--Brazil. Marine shrimp species cultured, 1989

Species	Farms	Harvest
	Percent	
Penaeus schmitti	89	13
P. subtilis	56	27
P. brasiliensis	33	-
P. penicilatus	22	17
P. vannamei	17	32
P. paulensis	NA*	11
Total	NA**	100

NA - Not available/not applicable
* Believed to be a relatively small number.
** Total exceeds 100 percent as many farms work on more than one species.
Source: Getulio de Souza Neiva, Chief DEPAQ/IBAMA, personal communications, June 13, 1990.

Appendix F3.--Brazil. Shrimp pond harvests and yields, 1990

State	Operating ponds	Yields	Estimated Harvest
	Hectares	Tons/Ha/Year	Metric tons
North			
Maranhao	230	0.60	138
Northeast			
Bahia	700	1.09	760
Ceara	430	0.47	202
Paraiba	172	0.64	110
Piaui	338	0.43	146
Rio Grande do Norte	150	0.61	113
South			
Santa Catarina	161	1.14	183
Total	2,181	0.76	1,652

Note: Available yield data is often based upon not always reliable industry estimates.
Source: Getulio de Souza Neiva, Chief, DEPAQ/IBAMA, June 13, 1990.

Appendix G1.--Brazil. Freshwater shrimp farms, 1989

State	Farms	Ponds
	Number	Hectares
North		
Amapa	-	-
Para	1	3
Northeast		
Maranhao	-	-
Piaui	2	6
Ceara	-	-
Rio Grande do Norte	4	32
Paraiba	2	5
Pernambuco	32	81
Alagoas	6	38#
Sergipe	5	13
Bahia	7	31
South		
Espirito Santo	13	25
Rio de Janeiro	15	49
Sao Paulo	1	1
Parana	2	3
Santa Catarina	3	26
Rio Grade do Sul	-##	-##
West		
Mato Grosso	1	3
Total	94*	318**

Independent reports suggest that this number is somewhat low. One company alone (Capiata Aquicultura) reports 54 ha of ponds.
One observer reports that in 1990 there were 23 small farms with a total pond area of 7.6 hectares. Sergio Zimmermann, personal communications, October 25, 1990.
* Other sources suggest in 1990 that there were over 100 farms.
** Other sources suggest the total area of ponds may be as high as 400 hectares. Aecio Moura, personal communications, May 14, 1990.
Note: Based on reports from other sources, the statistics in this appendix are probably an overly conservative estimate and do not include a substantial number of ponds, mostly those operated by farmers as a sideline to other crops.
Source: Getulio de Souza Neiva, Chief, DEPAQ/IBAMA, June 13, 1990.

Appendix G2.--Brazil. Marine shrimp farms, August 1987.

Company	Ponds	System	Yields	Species	State
	Hectares		Tons/ha*		
AGROPLAN	64	SI/H	NA	Ps	BA
Aquamaris Aquacultura Ltda.	NP	E/H	NA	-	PB
AQUA-SUL, S.A.	NP	E-SI-I/H	NA	Ps?	ES
Aquicultura Com. Ind, S.A. (SECOM)	NA	E/H	0.4	Pb, Psu	PI
Artemisa	NA	E/H	0.4	Pb, Ps,Psu	CE
Bahia Pesca	58	E/H	0.2	Pp,Ps	BA
(Fabio) Benayhon	NP	NA	NA	-	RN
CAMANOR	80	E	NA	Pb,Ps,Pv	RN
CAMASA	NP	E/H	NA	-	PA
Cammaroes do Para, S.A. (CAMPASA)	NP	SI	NA	Ps	PA
Carcinocultura Kammarus, S.A.	NP	E/H	NA	Ps	MA
CEPLAC	NP	E/H	NA	-	BA
CMEL	NP	NA	NA	-	BA
Companhia Brasileira de Aqui. (CBA)	700**	E/H	0.2	Psu, Pj	RN
Companhia Nordeste de Aqui. (CINE)	85	E	0.6	Pb, Ps, Psu	CE
CONVESCO	NP	E		Ps,Psu	MA
Crustaceos do Brasil, S.A. (CRUSA)	240	E/H	0.2	Psu	PI
Eldorado Agro-Industrial Ltda.	NP	E	NA	-	RN
Empresa Canoe de Camaroes	NP	NA	NA	-	CE
Empresa de Alimentos do NE (CALNE)	NP	E/H	NA	-	SE
Empresa Potiguar de Camaroes	5	E	NA	Ps	RN
ESNISA	NP	SI	NA	Ps	MA
Fazenda Camaroneira de Perises, S.A.	200	SI/H	NA	Ps	MA
(Henrique) Lage Salineira do NE	100**	E/H	NA	Pj	RN
Ilha Rasa Productos Marinhos Ltda.	NP	SI	NA	-	PR
Ilhas Mauranas Camarao, S.A.	30	SI/H	NA	Pb,Ps,Psu	NA
Jardimar	68**	NA	NA	-	CE
LUKA	NP	NA	NA	-	RN
LUSOMAR Ltd .	96	E-SI/H	0.2	Ps	SC
Maricultura da Bahia	300	SI/H	1.2	Ppe,Ps,Pv	BA
Maricultura do Nordeste, S.A.	NP	E/H	NA	-	RN
Mariscos do Brasil	84	E/H	NA	Psu	MA
MARPISA	72	NA	NA	-	PI
NORTEMAR Ltda.	NP	E/H	NA	Ps	BA
Paludo Agropesca	50	E	0.1	Pp	SC
PESCON	206	SI/H	NA	Ppe,Ps,Pv	BA
Pesqueira Capanema	179	E	0.2	Pb, Ps, Psu	CE
Recursos Naturais Aquicultura (RENA)	154	E/H	0.1	Ps,Psu	RN
Salinas Camaroes Cultivados, S.A.	2	E/H	NA	Pp,Ps,Pv	BA
Soagro Marino	NP	NA	NA	-	BA
Vale do Iguape	NP	NA	NA	-	BA
Valencia de Bahia Maricultura	NP	E/H	NA	-	BA
Total	2,773***	NA	NA	NA	NA

* Annual live weight figures
** Production stopped
*** Active area was 1,905 hectares.
Note: Available yield data is often based upon not always reliable industry estimates.
NA - Not available or not applicable
Key: Ponds: NP - No ponds constructed
System: E - extensive; SI - semi-intensive; I - Intensive; H - hatchery
Species: Pb - *P. brasiliensis*; Pj - *P. japonicus*; Pp - *P. paulensis*; Ppe - *P. penicillatus*; Ps - *P. schmitti*; Psu - *P. subtilis*; and Pv - *P. vannamei*.
State: BA - Bahia; CE - Ceara; ES - Espirito Santo; MA - Maranhao; PA - Para; PB - Paraiba; PI - Piaui, PR - Parana; RN - Rio Grande do Norte; SC - Santa Catarina; SE - Sergipe
Source: Marcos Rogerio Camara (UPPC/EMPARN) and Carlos Lamartine Torres Mello (SUDEPE), August 1987.

Appendix G3.--Brazil. Marine shrimp farms, August 1987.

State/Company	Ponds
	Hectares
Bahia	
Maricultura da Bahia	300
PESCON	206
AGROPLAN	64
Bahia Pesca	58
Salinas Camaroes Cultivados, S.A.	2
CEPLAC	NP
CMEL	NP
Soagro Marino	NP
Vale do Iguape	NP
Valencia de Bahia Maricultura	NP
NORTEMAR Ltda.	NP
Ceara	
Pesqueira Capanema	179
Companhia Nordeste de Aqui. (CINE)	85
Jardimar	68*
Artemisa	NA
Empresa Canoe de Camaroes	NP
Espirito Santo	
AQUA-SUL, S.A.	NP
Maranhao	
Fazenda Camaroneira de Perises, S.A.	200
Mariscos do Brasil	84
Carcinocultura Kammarus, S.A.	NP
CONVESCO	NP
ESNISA	NP
Para	
CAMASA	NP
Cammaroes do Para, S.A. (CAMPASA)	NP
Parana	
Ilha Rasa Productos Marinhos Ltda.	NP
Paraiba	
Aquamaris Aquacultura Ltda.	NP
Piaui	
Crustaceos do Brasil, S.A. (CRUSA)	240
MARPISA	72
Aquicultura Com. Ind, S.A. (SECOM)	NA
Rio Grande do Norte	
Companhia Brasileira de Aqui. (CBA)	700*
Recursos Naturais Aquicultura (RENA)	154
(Henrique) Lage Salineira do NE	100*
CAMANOR	80
Empresa Potiguar de Camaroes	5
(Fabio) Benayhon	NP
Eldorado Agro-Industrial Ltda.	NP
LUKA	NP
Maricultura do Nordeste, S.A.	NP
Santa Catarina	
LUSOMAR Ltds.	96
Paludo Agropesca	50
Sergipe	
Empresa de Alimentos do NE (CALNE)	NP
Unknown	
Ilhas Mauranas Camarao, S.A.	30

* Production stopped
NA - Not available or not applicable
NP - No ponds constructed
Source: Marcos Rogerio Camara (UPPC/EMPARN) and Carlos Lamartine Torres Mello (SUDEPE), August 1987.

Appendix G4.--Brazil. Marine shrimp farms, 1988.

Company	Ponds♦	System	Yields	Species	State
	Hectares		Tons/ha*		
Agroplan	67	SI/H	1.6	Ps	BA
Aquamaris Maricultura	88	E	0.8	Psu	RN
Camanor	63	E	0.4	Ps,Psu	RN
Capanema	204	SE	0.5	Ps,Psu	CE
CINA	85	SE	0.7	Ps,Psu	CE
Crusa	227	E/H	0.3	Pb,Ps,Psu	PI
Maricultura de Bahia	512	SI/H	0.7	Ppe,Ps,Pv	BA
Marine S.A.	-#	SI	NA	NA	RN
Mariscos	134	E	0.2	Pb,Ps,Psu	PI
Paludo Agropesca	55	SE	0.4	Pp	SC
Perises	150	SI	1.1	Ps,Psu	NA
PESCON	253	E/H	0.3	Ppe,Ps,Pv	BA
SECOM	154	SE/H	0.6	Pb,Ps,Psu	PI
Total	1,993	NA	0.6	NA	NA

♦ Presumably active ponds.
* Annual live weight figures
# Under construction
Note: Available yield data is often based upon not always reliable industry estimates.
NA - Not available or not applicable
Key: Ponds: NP - No ponds constructed
System: E - extensive; SI - semi-intensive; I - Intensive; H - hatchery
Species: Pb - P. brasiliensis; Pj - P. japonicus; Pp - P. paulensis; Ppe - P. penicillatus; Ps - P. schmitti; Psu - P. subtilis; and Pv - P. vannamei.
State: BA - Bahia; CE - Ceara; ES - Espirito Santo; MA - Maranhao; PA - Para; PB - Paraiba; PI - Piaui, PR - Parana; RN - Rio Grande do Norte; SC - Santa Catarina; SE - Sergipe
Source: Yosuke Hirono, Survey Report: Situation on Brazilian Shrimp Farming Practice, April 1988.

Appendix G5.--Brazil. Marine shrimp farms, 1990

Company	Ponds	System	Yields	Species	State
	Hectares		Tons/ha*		
Aquamaris	200	E	0.3	Psu	PB
Artemisa	200	E	0.3	Ps,Psu	CE
Bahia Pesca, S.A.	80	E/H	0.4	Ppe,Ps,Psu	BA
CAMANOR	78	E-SI/H	0.6	Pa**,Ps	RN
Camaroneira de Perises	250	E/SI	0.4	Ps,Psu	NA
CINA	88	E-SI	1.0	Ps,Psu	NA
C. Done	30	E	0.3	Ps,Psu	NA
Maricultura de Bahia	550	SI/H	1.2	Ppe,Pv	BA
Marine	80	E	0.6	Pa**,Ps	NA
Mariscos do Brasil, S.A.	250	E	0.3	Ps,Psu	MA
MARPISA	80	E	0.2	Ps,Psu	PI
Paludo	80	E	0.3	Pp	SC
Pescon	360	SI/H	0.8	Ppe	BA
Pesquera Capanema	200	E	0.4	Ps,Psu	NA
SECOM	200	E/H	0.4	Psu	NA
Valencia Maricultura	90	SI/H	NA	Ppe	BA

NA - Not available or not applicable
Note: Available yield data is often based upon not always reliable industry estimates.
Key: Ponds: NP - No ponds constructed
System: E - extensive; SI - semi-intensive; I - Intensive; H - hatchery
Species: Pa - P. aztecus*; Pb - P. brasiliensis; Pj - P. japonicus; Pp - P. paulensis; Ppe - P. penicillatus; Ps - P. schmitti; Psu - P. subtilis; and Pv - P. vannamei.
State: BA - Bahia; CE - Ceara; ES - Espirito Santo; MA - Maranhao; PA - Para; PB - Paraiba; PI - Piaui, PR - Parana; RN - Rio Grande do Norte; SC - Santa Catarina; SE - Sergipe
* Annual live weight figures
** Probably incorrectly identified. Probably is P. subtilis.
Source: Iracema Andrade Nasoimento, Coordenadora, Mastrado em Prucao Aquatica, Instituto de Biologia, UFBA, personal communication, May 14, 1990.

Appendix G6.--Brazil. Marine shrimp farms, May 1990.

Company	Ponds*	System	Yields 1989	Harvest 1989	Species	State
	Hectares		Tons/ha**	Tons		
Aquamaris-Aquacult.	160	SI/H	0.5	50	Psu	PB
Artemisa-Aquacultura	160	E	0.4	42	Ps,Psu	CE
Augusto Paulo Salpon	10	SI	1.3	13	Ps	SC
Bahia Pesca***	60	NA/H	-	-	-	BA
CAMANOR/Aquitec	80	SI/H	0.6	48	Ps,Psu	RN
Cammarus	50	SI	0.6	28	Psu	MA
CANORTE	30	SI	1.0	20	NA	RN
Companhia Nordeste de Aqui. (CINE)	80	SI	0.8	64	Psu	CE
CONMAR	40	SI	NA	-	Ps,Psu	PI
Crustaceos do Brasil (CRUSA)***	240	NA/H	-	-	-	PI
El Dorado***	50	NA	-	-	-	RN
Emp. Pesq. Agr. (EMPARN)	31	NA/H	-	-	-	RN
Fazenda Perizes	250	SI	0.6	90	Ps,Psu	MA
Formosa Camaroes	40	I	2.0	12	Ps,Psu	RN
Jardimar Aquicultura	75	E	0.3	21	Ps,Psu	CE
Luna Aquicultura	12	SI	0.6	-	Ps,Psu	PB
Lusomar	96	SI	0.8	70	Ps	
Maricultura de Bahia	500	SI/H	1.0	400	Pv Ps	BA
Marine	56	SI	0.3	14	Ps,Psu	RN
Mariscos do Brasil	134	E	0.3	35	Ps,Psu	
Mariscos do Piaui	72	E	0.4	8	Psu	PI
NORTEMAR***	120	NA/H	-	-	-	BA
Ocean Mariculture***	70	NA/H	-	-	-	BA
Paludo Agropesca	150	SI	1.5	80	Ps	SC
Pesq. Reconc. (PESCON)	250	SI/H	0.8	100	Ps,Pv	BA
Potiguar Camaroes	50	NA	-	-	-	RN
Rec. Naturais (RENA)***	160	NA/H	-	-	-	RN
SECOM-Aquicultura	200	SI/H	0.4	53	Ps,Psu	PI
Sohagro***	150	-	-	-	-	BA
Valença Camaroes***	300	NA/H	-	-	-	BA
Total	3,851	NA	NA	1,287	NA	NA

Note: While the above list is believed to include most of the important Brazilian farms, it is not a complete list. Available yield data is often based upon not always reliable industry estimates.
* Ponds constructed, not necessarily in operation
** Annual liveweight figures. Yield calculation is based on harvests from ponds actually in operation.
*** Inactive
NA - Not available or not applicable
Key: Ponds: NP - No ponds constructed
System: E - extensive; SI - semi-intensive; I - intensive; H - hatchery
Species: Pb - P. brasiliensis; Pj - P. japonicus; Pp - P. paulensis; Ppe - P. penicillatus; Ps - P. schmitti; Psu - P. subtilis; and Pv - P. vannamei.
State: BA - Bahia; CE - Ceara; ES - Espirito Santo; MA - Maranhao; PA - Para; PB - Paraiba; PI - Piaui, PR - Parana; RN - Rio Grande do Norte; SC - Santa Catarina; SE - Sergipe
Sources: MCR-Aquaculture and Associaço Brasileira dos Criadores de Camarao (ABCC) in Silvio R.C. Coelho, Itamar de Paiva Rocha, and Lenin E. Paredes. "El Cultivo de Camaron Marino en el Brasil," Joao Pessoa (PB), May 1990.

Appendix G7.--Brazil. Marine shrimp farms, May 1990.

State/Company	Ponds		Harvest	
	Constructed*	Operating	1989	1990P
	Hectares		Tons	
Bahia				
Bahia Pesca*	60	-	-	-
Maricultura de Bahia	500	500	400	600
NORTEMAR***	120	-	-	-
Ocean Mariculture***	70	-	-	-
Pesq. Reconc. (PESCON)	250	200	100	160
Sohagro***	150	-	-	-
Valença Camaroes***	300	-	-	-
Ceara				
Artemisa-Aquacultura	160	150	42	57
Cia. Nordeste de Aqui. (CINE)	80	80	64	70
Jardimar Aquicultura	75	75	21	25
Maranhao				
Cammarus	50	50	28	30
Fazenda Perizes	250	180	90	108
Paraiba				
Aquamaris-Aquacult.	160	160	50	80
Luna Aquicultura	12	12	-	30
Piaui				
CONMAR	40	30	-	24
Crustaceos do Bra. (CRUSA)***	240	-	-	-
Mariscos do Brasil	134	134	35	50
Mariscos do Piaui	72	24	8	12
SECOM-Aquicultura	200	150	53	60
Rio Grande do Norte				
CAMANOR/Aquitec	80	80	48	50
CANORTE	30	23	20	23
El Dorado***	50	-	-	-
Emp. Pesq. Agr. (EMPARN)	31	-	-	-
Formosa Camaroes	40	6	12	20
Marine	56	41	14	20
Potiguar Camaroes	50	-	-	-
Rec. Naturais (RENA)***	160	-	-	-
Santa Catarina				
Augusto Paulo Salpon	10	10	13	13
Lusomar	96	96	70	80
Paludo Agropesca	150	55	80	90
Total	3,851	2,181	1,287	1,652

* Ponds constructed, not necessarily in operation
** Annual liveweight figures. Yield calculation is based on harvests from ponds actually in operation.
*** Inactive
Note: Available yield data is often based upon not always reliable industry estimates.
NA - Not available or not applicable
P - Projected
Key: Ponds: NP - No ponds constructed
System: E - extensive; SI - semi-intensive; I - intensive; H - hatchery
Species: Pb - *P. brasiliensis*; Pj - *P. japonicus*; Pp - *P. paulensis*; Ppe - *P. penicillatus*; Ps - *P. schmitti*; Psu - *P. subtilis*; and Pv - *P. vannamei*.
State: BA - Bahia; CE - Ceara; ES - Espirito Santo; MA - Maranhao; PA - Para; PB - Paraiba; PI - Piaui, PR - Parana; RN - Rio Grande do Norte; SC - Santa Catarina; SE - Sergipe
Sources: Sources: MCR-Aquaculture and Associaço Brasileira dos Criadores de Camarao (ABCC) in Silvio R.C. Coelho, Itamar de Paiva Rocha, and Lenin E. Paredes. "El Cultivo de Camaron Marino en el Brasil," Joao Pessoa (PB), May 1990.

Appendix G8.--Brazil. Southern farms

State/Company	Pond Area	System
	Hectares	
Santa Estarina		
Paludo Agro	56	SE
Augusto Sal.	10	SE
Cavanholo	16	SE
Caquna	6	SE
Yakulti	20	SI
Pazarras	8	SE
Rio Grande do Sul		
Taruaudaí	20	SE

SE - Semi-extensive
SI - Semi-intensive
Source: Luis Vinatea Arena, personal communications, September 3, 1991.

Appendix G9.--Brazil. Marine shrimp farms, May 1990.

State/Company	Farms		Ponds		Species	Harvest
	Operating	Planned	Planned	Actual		1990P
	Number		1,000 Hectares			Tons
Bahia	10	-	2.0	0.8	Pp,Ps,Pv	495
Ceara	4	-	0.5	0.5	Ps,Psu	130
Rio G. do Norte	9	1	1.8	0.2	Ps,Psu	100
Santa Catarina	4	1	0.2	0.1	Pp,Ps	100
Piaui	4	-	1.5	0.3	Ps,Psu	60
Maranhao	5	-	0.9	0.2	Ps,Psu	60
Paraiba	1	-	0.2	0.2	Psu	30
Para	1	4	0.1	Negl	Ps,Psu	5
Pernambuco	2	-	0.1	-	NA	-
Sergipe	1	-	0.2	-	NA	-
Total	41	6	7.5	2.3	NA	980

NA - Not available/not applicable
Notes: Discrepancies with appendix R are unexplained. Available yield data is often based upon not always reliable industry estimates.
* Presumably ponds constructed, not necessarily in operation
** Annual liveweight figures. Yield calculation is based on harvests from ponds actually in operation.
*** Inactive
NA - Not available or not applicable
Key: Species: Pb - P. brasiliensis; Pj - P. japonicus; Pp - P. paulensis; Ppe - P. penicillatus; Ps - P. schmitti; Psu - P. subtilis; and Pv - P. vannamei.
State: BA - Bahia; CE - Ceara; ES - Espirito Santo; MA - Maranhao; PA - Para; PB - Paraiba; PI - Piaui, PR - Parana; RN - Rio Grande do Norte; SC - Santa Catarina; SE - Sergipe
Sources: Getulio de Souza Neiva, Chief, DEPAQ/IBAMA, May 1990.

Appendix G10.--Brazil. Freshwater prawn farms, 1990

Region/State	Farms	Ponds
	Number	Hectares
North/Northeast		
Para	2	8
Piaui	2	6
Ceara	2	5
Rio Grande de Norte	4	32
Paraiba	2	5
Pernambuco	50	200
Alagoas	6	60
Sergipe	5	13
Bahia	9	50
Center-South		
Mato Grosso do Sul	3	40
Goias	3	20
Minas Gerais	5	20
Espirito Santo	80	80
Rio de Janeiro	15	50
Sao Paulo	100	80
Parana	4	20
Santa Catarina	14	50
Rio Grande do Sul	23	8
Total	329	747

Notes: These numbers are low estimates.
Source: Wagner Controni Valenti, Universidade Estadual Paulista, personal communications, June 10, 1991.

Appendix H1.--Brazil. Marine shrimp hatcheries

Species	Hatcheries	Capacity
	Number*	Million pl per month
Marine		
Penaeus subtilis	4	30**
P. vannamei	3	30**
P. schmitti	3	15**
P. penicillatus	2	10**
P. paulensis	1	5**
P. aztecus	NA	NA***
P. brasiliensis	NA	NA***
	NA	90
Freshwater		
M. rosenbergii	23	30

* Numbers do not add as some hatcheries do more than one species
** Pl10
*** Believed to be relatively small
Source: Itamar Rocha, Director Presidente, MCR Aquacultura Ltda., personal communications, February 8, 1990.

Appendix H2.--Brazil. Marine shrimp hatcheries, 1988

Company	Capacity	Species#	State
	Million pl per month		
Agroplan	10.0	Ps	BA
Aquamaris	6.5	Psu	RN
Barra da Lagoa	NA*	Pj, Ps	SC
CRUSA	5.0	Pb,Ps,Psu	PI
Maricultura de Bahia	5.5	Ppe,Ps,Pv	BA
PESCON	3.5	Ppe,Ps,Pv	BA
SECOM	2.0	Pb, Ps,Psu	PI

Note: Individual hatchery information is not available for all of the hatcheries included in appendix T.
Source does not indicate whether species refer to hatchery, growout ponds, or both.
Key: Species: Pa - P. aztecus; Pb - P. brasiliensis; Pj - P. japonicus; Pp - P. paulensis; Ppe - P. penicillatus; Ps - P. schmitti; Psu - P. subtilis; and Pv - P. vannamei.
State: BA - Bahia; CE - Ceara; ES - Espirito Santo; MA - Maranhao; PA - Para; PB - Paraiba; PI - Piaui, PR - Parana; RN - Rio Grande do Norte; SC - Santa Catarina; SE - Sergipe
* Plus nauplii production.
Source: Yosuke Hirono, Survey Report: Situation on Brazilian Shrimp Farming Practice, April 1988 and Luis Vinatea Arana, personal communications, September 3, 1991.

Appendix H3.--Brazil. Marine shrimp hatcheries, 1990

Company	Capacity	Species	State
	Million pl per month		
Bahia Pesca	0.5	Pp,Ps,Psu	BA
Barra da Lagoa	10*	Pj, Ps	SC
Camanor/Aquitec	2.0	Pa,Ps	PI
Maricultura de Bahia	10.0	Pv	BA
Mariscos do Brazil, S.A.	1.0	Psu	MA
PESCON	4.0	Pp	BA
Valencia Maricultura	0.5	Pp	BA

Note: Individual hatchery information is not available for all of the hatcheries included in appendix T.
Key: Species: Pa - P. aztecus; Pb - P. brasiliensis; Pj - P. japonicus; Pp - P. paulensis; Ppe - P. penicillatus; Ps - P. schmitti; Psu - P. subtilis; and Pv - P. vannamei.
State: BA - Bahia; CE - Ceara; ES - Espirito Santo; MA - Maranhao; PA - Para; PB - Paraiba; PI - Piaui, PR - Parana; RN - Rio Grande do Norte; SC - Santa Catarina; SE - Sergipe
* Plus nauplii production of about 60 million pl per month.
Source: Dra. Iracema Andrade Nascimento, Mestrado em Producao Aquatica, Instituto de Biologia, UFBA., May 14, 1990 and Luis Vinatea Arana, personal communications, September 3, 1991.

Appendix H4.--Brazil. Marine shrimp hatcheries, 1990

Company	Capacity	Species	State
	Million pl per month		
Aquamaris-Aquacult.	10	Psu	PB
Bahia Pesca***	-	NA	BA
Barra da Lagoa	NA*	Pj, Ps	SC
Camanor/Aquitec	8	Ps,Psu	RN
Crustaceos do Brasil***	-	NA	PI
Emp. Pesq. Agr. (EMPARN)***	8	NA	RN
Maricultura de Bahia	17	Pv,Ps	BA
NORTEMAR***	-	NA	BA
Ocean Mariculture***	-	NA	BA
Pesq. Reconc. (PESCON)	4	Ps,Pv	BA
Rec. Naturais (RENA)	5	NA	RN
SECOM-Aquicultura	4	Ps,Psu	PI
Valença Camaroes***	-	NA	BA
Total	90	NA	NA

Note: Individual hatchery information is not available for all of the hatcheries included in appendix T.
Key: Species: Pa - *P. aztecus*; Pb - *P. brasiliensis*; Pj - *P. japonicus*; Pp - *P. paulensis*; Ppe - *P. penicillatus*; Ps - *P. schmitti*; Psu - *P. subtilis*; and Pv - *P. vannamei*.
State: BA - Bahia; CE - Ceara; ES - Espirito Santo; MA - Maranhao; PA - Para; PB - Paraiba; PI - Piaui, PR - Parana; RN - Rio Grande do Norte; SC - Santa Catarina; SE - Sergipe
* Plus nauplii production of about 60 million pl per month.
Source: Sources: MCR-Aquaculture and Associaço Brasileira dos Criadores de Camarao (ABCC) as prepared by Getulio de Souza Neiva, Chief, DEPAQ/IBAMA, May 1990 and Luis Vinatea Arana, personal communications, September 3, 1991.

Appendix H5.--Brazil. Freshwater shrimp hatcheries, 1989

Region/state	Hatcheries			Total
	Commercial	Farm	Government	
		Number		
North				
Amapa	-	-	-	-
Para	-	1	-	1
Northeast				
Maranhao	-	-	-	-
Piaui	-	1	-	1
Ceara	-	-	-	-
Rio G. do Norte	1	1	1	3
Paraiba	1	-	-	1
Pernambuco	2	1	1	4
Alagoas	-	1	-	1
Sergipe	-	1	-	1
Bahia	1	-	-	1
South				
Espirito Santo	-	-	1	1
Rio de Janeiro	1	3	1	5
Sao Paulo	1	-	-	1
Parana	-	1	-	1
Santa Catarina	1	-	1	2
West				
Mato Grosso	-	-	-	-
Total	8	10	5	23

Source: Getulio de Souza Neiva, Chief, DEPAQ/IBAMA, June 13, 1990.

Appendix H6.--Brazil. Freshwater prawn hatcheries, 1990.

Region/State	Hatcheries			Total
	Commercial	Farm	Government	
		Number		
North/Northeast				
Para	-	1	-	1
Puaui	-	1	-	1
Rio Grande do Norte	1	2	1	4
Paraiba	1	1	-	2
Pernambuco	1	1	1	3
Alagoas	-	1	-	1
Sergipe	-	1	-	1
Bahia	1	2	-	3
Center/South				
Goias	-	1	-	1
Espirito	-	1	1	2
Rio de Janeiro	1	2	1	4
Sao Paulo	1	1	1	3
Parana	-	1	-	1
Santa Catarina	1	1	1	3
Total	7	17	6	30

Source: Source: Wagner Contron Valenti, Universidade Estadual Paulista, personal communications, June 10, 1991.

Appendix I1.--Brazil. Shrimp culture methods

System	Farms	Pond Area	Yield	Proportion
	Number	Hectares	T/ha/year	Percent
Extensive	2	209	0.3	10
Semi-extensive	13	1,201	0.5	55
Semi-intensive	4	765	1.1	35
Intensive	1	6	2.0	Negl

Source: MCR Aquaculture (consulting company) and the Associaçao Brasileira dos Criadores de Camarao (ABCC) as cited in R.C. Coelho, Itamar de Paiva Rocha, and Lenin E. Paredes. "El Cultivo de Camaron Marino en el Brasil," Joao Pessoa (PB), May 1990.

Appendix I2.--Brazil. Shrimp culture methods

Characteristic	Type		
	Semi-extensive	Semi-intensive	Intensive
Nursery ponds			
Area	1-2 ha	0.1-1.0 ha	<0.1 ha
Stocking density			
Initial	40-60/m^2	100-150/m^2	150/m^2
Final	20-30/m^2	60-90/m^2	90/m^2
Duration	45 days	40 days	40 days
Survival	50%	60%	60%
Feeding rates	-	NA	NA
Annual cycles	6	6	6
Growout ponds			
Area	10-25 ha	5-20 ha	<0.5 ha
Stocking density			
Initial	1.5-2.0/m^2	3-7/m^2	>10/m^2
Final	NA	NA	NA
Water exchange	2-5%	5-15%	10-50%
Feeding rates	-	3-5%*	3-5%*
Duration	70-90 days	60-90 days	60-90 days
Survival	70%	70%	70%
Harvest weight	13-18 g	10-18 g	10-18 g
Annual yield	0.4-0.8t/ha	1.0-1.2t/ha	>3.0t/ha

* Percent of biomass
Source: Getulio de Souza Neiva, Chief, DEPAQ/IBAMA, June 13, 1990.

Appendix J.--Brazil. Shrimp diseases of various etiology

Disease	Species	Life stage	Reference
Viruses			
Baculovirus penaei	P. schmitti	NA	1
	P. vannamei	l/pl	1
	P. penicillatus	l/pl	1
	P. subtilis	pl	3
MBV	P. monodon	a	2
IHHNV (RDS?)	P. vannamei	a*	2
	P. monodon	j**	2
HPV	P. schmitti	j	2
	P. vannamei	a	2
Protozoans			
Gregarine	P. vannamei	l/pl	1
	P. penicillatus	l/pl	1/2
	P. schmitti	NA	1
Zoothamnium	P. penicillatus	j	2
	P. vannamei	j/a	2
	P. monodon	l**	
Bacterial infection			
Bacterial enteritis	P. penicillatus	l	2
Nutritional/environmental			
Black death	P. penicillatus	a	2
Muscle cramp	P. brasiliensis	a	4

NA - Not available
* bent rostrum
** old runt juveniles
Sources: 1) D. Lightner, diagnostic findings (Tu86-76); 2) Lightner, "Summary of findings from shrimp and other samples from Maricultura and PESCOM," Environmental Research Laboratory Report, University of Arizona, 1987;
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4.4

CHILE

Chile has not yet developed a shrimp aquaculture industry. A variety of factors suggest that the country has a limited potential to culture shrimp. Indigenous species are untried in pond culture. Climatic factors, especially low seasurface temperatures, as a result of the Humboldt Current, and arid conditions probably preclude the development of a competitive marine shrimp culture industry. Some observers believe intensive operations may be possible, but such assessments are highly speculative at this point. Chilean researchers have conducted considerable research on shrimp culture, especially freshwater species. Chile is developing the most important aquaculture industry in Latin America, based on salmon and other species. This developing industrial base could enable the country to play a role in the development of shrimp culture industries in other Latin American countries.

CONTENTS

I. CAPTURE FISHERY

Chile conducts a small shrimp fishery, primarily for a *Pandalid* species (*Heterocarpus reedi)* and a variety of other species (including *Pleuroncodes monodon*).[1] The 1989 catch was about 5,600 metric tons (t) and has been increasing in recent years after reaching low levels of less than 3,000 t in 1985 and 1986. Given the cold sea temperatures off Chile, commercial stocks of *Penaeid* shrimp do not occur. The shrimp fishery is conducted along the central coast and is strictly regulated because overfishing and climatic fluctuations reduced catches in previous years. Catches approaching 10,000 t were reported in the early 1970s.[2] About 40 trawlers are believed to participate in the fishery, although the season is restricted to a relatively short period.

II. AQUACULTURE INDUSTRY

Chile is emerging as a Latin American leader in aquaculture. Many Chilean observers are convinced that aquaculture offers the most promising opportunities in the fishing industry.[3] Development has primarily focused on salmon, but commercial operations also exist for trout, mussels and others mollusks, seaweed, and various other species. While prospects for a shrimp culture industry are currently limited in Chile, the expanding service industry supporting salmon growers and other aquaculturists could assist shrimp farmers in other Latin American countries.

Chile is a major producer of fishmeal. Some of the country's important fishmeal companies, are producing high quality fishmeal for use in aquaculture feeds. This meal is currently used primarily to produce salmon feed for domestic growers, but may in the future play an important role in the growing regional demand for shrimp feed. Several countries (Brazil, Colombia, Ecuador, Honduras, and Mexico) with significant growout potential have only a limited capability to produce fishmeal needed for manufacturing feed. Shrimp farmers in several Latin American countries (Columbia and Panama) believe that poor quality feed currently impairs their ability to increase yields. Thus further expansion of Chile's aquaculture and feed manufacturing base could benefit growers throughout Latin America.

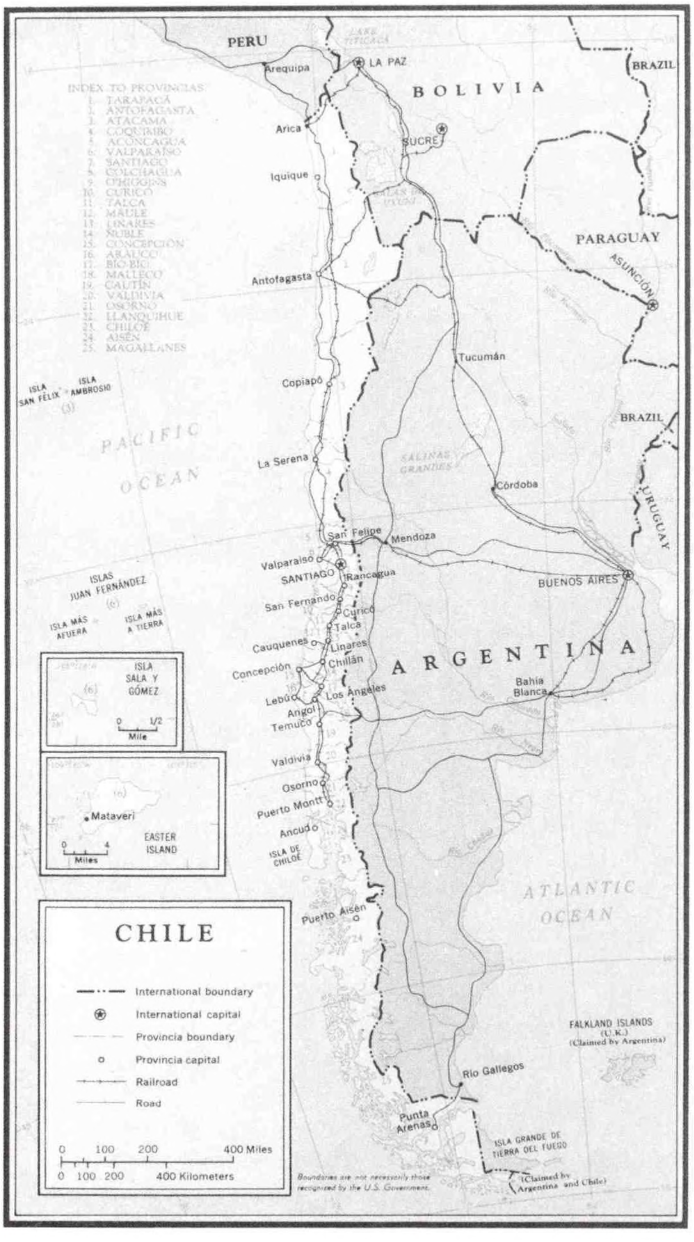
III. GROWING CONDITIONS

Chile appears to have only a limited potential to culture shrimp. As in Argentina[4], Chile's southern cone neighbor, a temperate climate and absence of a well-researched indigenous marine species conducive to pond culture limits the development of the industry. Potential shrimp farmers face several additional problems in that Chile's northern coast is one of the most arid environments on earth. Little freshwater is available for shrimp farmers and many economic interests compete for the limited water which is available. The northern flowing Humboldt Current sharply depresses sea surface temperatures along the coast. Many areas of Chile also report very wide daily temperature ranges.[5] One important Chilean researcher is convinced that the absence of a suitable indigenous species is proving the major impediment to the industry's development.[6] These factors probably preclude the development of any significant marine shrimp culture industry in the foreseeable future.

IV. RESEARCH

Despite the above limitations, some research groups have expressed an interest in shrimp culture. Researchers have worked on both marine and freshwater species, but have concentrated primarily on the freshwater species.

Marine: The Universidad Catolica del Norte at Coquimbo (UCN) launched a marine shrimp *(Penaeus vannamei)* maturation project. University officials report considerable progress in both maturation and growout (in tanks).[7] The Universidad de Antofagasta (UA) is cooperating with the UCN *Penaeid* maturation work. UA researchers since 1985 have worked with two species (*P. vannamei* and *P. stylirostris*). Researchers concluded that extensive cultured operations would be limited to the warm months of October-April. The research evaluated a variety of environmental parameters and growout systems and suggests that controlled environment intensive systems may be the most suitable approach for Chilean growers.[8] One researcher reported that yields of 3.6 t per hectare (ha) could be obtained,[9] but the commercial costs of production are yet to be determined. The



Universidad Catolica at Santiago has reportedly done some work on polyculture.[10] Shrimp culture was reportedly one of the subjects discussed with a visiting Mexican technical mission during October 1990.[11] The Chilean Government reported in 1991 that private groups in Iquique were considering a shrimp culture project, but even if they decided favorably it would be 1-2 years before production could begin.[12] While Chilean work on marine shrimp culture has been limited, one Chilean group is studying another marine crustacean, southern king crab (*Lithodes antarcticus*). The Instituto de la Patagonia efforts are primarily directed at restocking depleted wild populations.[13]

Freshwater: Chilean researchers have been more active with freshwater shrimp culture. Some observers believe that water temperatures in central and southern Chile may not permit the culture of *Macrobrachium rosenbergii*, the principal freshwater species cultured in most other countries.[14] As a result, Chilean researchers have been assessing the potential of indigenous species. Various academic groups have focused on (*Cryphiops caementarius*), a species occurring off northern Chile and southern Peru. One observer believes that the research, concentrating on growth and nutrition, has laid the foundation for commercial culture.[15] The Universidad Arturo Prat (UAP) has also worked with *C. caementarius*. They have collected juveniles in the wild and conducted trial growout runs. Researchers report satisfactory results, but have had problems with cannibalism when they attempted to increase densities.[16] The University of Chile has also sponsored work on *C. caementarius*, part of which was conducted with funds from a Canadian non-governmental organization. Research focused on the northerly Río Loa (near Antofagasta)[17], but one of the researchers now wants to conduct similar studies in the more southerly Río Choapa.[18] A UCN group has reportedly produced *C. caementarius* postlarvae (pl) at its hatchery[19] and conducted growout trials in net pens at Recoleta, along the central coast (Region IV).[20] A group of researchers a the Instituto Profesional de Osorno (IPO) is convinced that the species can be cultured commercially in Chile.[21] Other researchers have identified another indigenous species (*Parastacus nicoleti*) as offering some advantages for commercial culture, primarily the ease with which pl can be produced.[22] One IPO researcher interested in the *Parastacidae* family reports that their work focuses not only on culturing freshwater shrimp for human consumption, but also for possible restocking of wild stocks or for feeding other species being cultured.[23] Another IPO researcher is working on *Artemia*.[24] The UA is also researching freshwater shrimp (*C. caementarius*) and *Artemia* culture.[25] The Chilean Development Corporation (CORFO) has expressed some interest in freshwater shrimp culture.

V. FARMS

Despite the technical advances, no commercial farms have yet been established. The U.S. Embassy in Santiago reported that some individuals were culturing local freshwater shrimp in 1986, but this probably referred to the various research efforts and trial runs.[26] One report suggests that there were experimental trials in northern Chile (Arica) in the late 1960s or early 1970s, which achieved some good results, but few details are available.[27] FAO aquaculture statistics do not report any cultured shrimp harvest in Chile.

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ENDNOTES

SECTION I (Capture Fishery)

1. A good description of the fishery and export markets was prepared by IFOP in 1984 and 1985. IFOP, *Diagnostico de las Principales Pesquerias Nacionales Demersales (Crustaceos) Zona Central*, Vol. 1-3, 1984-85.

2. The Servicio Nacional de Pesca (SERNAP) set annual quotas of 4,000 t in the mid 1980s after catches fell to the 2,000-3,000 t level. Instituto de Fomento Pesquero (IFOP), "Diagnostico de las Principales Pesqueras Nacionales Demerseales (Crustaceos) Zona Central: I. Estado de Situación del Recurso," *Estudios y Proyectos de Desarrollo Pesquero*, May 1987, SI 61.

SECTION II (Aquaculture Industry)

3. "Pesquerias: Perspectivas y Desafios para la Decada de los 90," *Chile Pesquero* October-November 1990, No. 60, 53-57.

SECTION III (Growing Conditions)

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SECTION IV (Research)

7. Jaime Meruane Zumelzu, Department of Aquaculture Director, Universidad Catolica del Norte, personal communications, January 4, 1991.

8. R. Wilson, R. Ramos, and O. Zuñiga, "Perspectivas de desarrollo del cultivo de camarones peneidos en el norte de Chile, *Manejo y Desarrollo Pesquero*, (Universidad Catolica de Valparaíso: Valparaíso, Chile, 1987), 243-249; O. Zuñiga, R. Ramos, and R. Wilson, "Introduccion, Aclimatacion y Crecimiento de los Camarones *Penaeus vannamei* Y *Penaeus stylirostris* en el Norte de Chile," *Estudios Oceanologicos, Vol. 7, 1988;* R. Ramos, O. Zuñiga, and R. Wilson, "Introduccion de Camarones Peneidos en el Norte de Chile," *Boletin: Red Acuicultura*, Vol. 3, No. 1, January-April 1989; R. Wilson, R. Ramos, O. Zuñiga, "Resultados Preliminares de Aclimatacion de Camarones Penidos en el Norte de Chile," paper delivered at the III Congreso Latinoamericano Sobre Ciencias de Mar (COLACMAR), Cumana, Venezuela, October 1989; and O. Zuñiga, R. Ramos, R. Wilson, and E. Retamales, "Efecto de la Densidad y Temperatura en el Cultivo de *Penaeus vannamei* (Crustacea: Penaeidae)," *X Jornadas de Ciencias del Mar*, Santiago, 1990.

9. O. Zuñiga, R. Ramos, and R. Wilson, "Influencia de la Densidad en el Crecimiento de Juveniles de *Penaeus vannamei*, Cultivados en Piscinas Bajo Invernadero," *VIII Jornadas de Ciencias del Mar*, Talcahuano, 1988.

10. M. Avila, "El efecto del policultivo del pez, *Mugil curema*, a varios densidades de siembra con la produccion de *Penaeus vannamei* y en la calidad de agua en estanques de tierra," Licenciatura thesis in bilology, Catholic University of Chile, in preparation, 1990.

11. "Mision Pesquera Mexicana Visita Chile," *Aquanoticias Internacional*," December 1990, pp. 12-13.

12. Rivas, SERNAP, Iquique, as cited by Rojas, *op. cit.*

13. "Explotacion del Recurso Centolla," *Chile Pesquero* October-November 1990, No. 60, p.8.

14. Julio Luna, *op. cit.*

15. Gonzalo Rojas Lanchipa, Instituto de Fomento Pesquero, personal communications, February 15, 1991.

16. UAP researchers report other difficulties, primarily associated with production of postlarval seedstock. Researchers continue to experience difficulty with hatchery production and report that inducing spawning is an especially serious problem. In addition, the species has numerous larval stages, many of which have very demanding environmental requirements. The varied requirements result because life cycle stages vary from freshwater river and brackish esturine environments. Gustavo Herrera and Gabriel Claramunt, Departamento Ciencias del Mar, Universidad Arturo Prat, personal communications, March 14, 1991.

17. Matilde López, Elio Segovia, and Denis Alfaro, "Microalgas: Su importancia como recurso alimemtario de camaron de rio del norte de Chile, *Cryphiops caementarius* (Molina, 1982)," *Medio Ambiente*, 1986, Vol. 8, No. 1, pp. 39-47.

18. The scarcity and competing demands for water in northern Chile has prompted researchers to assess rivers further south. Matilde López, Universidad de Chile, personal communications, February 12, 1991.

19. Miguel Rivera, Jaime Meruane, Ronald Gil, "Effects of Salinity and Food on Larval Survival of *Cryphiops caementarius* (Molina, 1782) (Crustacea: Palaemonidae)," reprinted from *Reports of the Usa Marine Biological Institute*, Kochi University, December 1987, No. 9, pp. 207-214.

20. A project to evaluate the culture of *C. caementarius* in the Rio del Norte (Region IV) is also underway. Jaime Meruane Zumelzu, Departamento de Acualcultura, Universidad Catolica del Norte, personal communication, February, 25, 1991. Also see Miguel Rivera, *Informe Final Presentado a CORFO*, 1988.

21. The IPO researchers worked with the species as part of a polyculture with mullet. O. Zuñiga, R. Ramos, and J. Revuelta, "Policultivo del Camaron de Rio (*Cryphipos caementarius*) y Lisa (*Mugil cephalus*) en estanques," *Estudios Oceanologicos, 1987, No. 6, 67-77.*

22. E. Rudolph and L. Zapata, "Desarrollo embrionario y postlarval del Camarón de las Vegas (*Parastacus nicoleti*), *Biota*, 1986, Vol. 2, 37-50.

23. Erich Rudolph, Instituto Profesional de Osorno, personal communications, March 27, 1991.

24. Dr. Gonzalo Gajardo is working on population genetics. *Artemia Newsletter*, No. 12.

25. P. Zavala, R. Ramos, and O. Zuñiga, "Ensayo de Dietas en el Crecimiento de Post-Larvas de *Cryphiops caementarius* (Crustacea: Palaemonidae)," *VIII Jornadas de Ciencias del Mar*, Talcahuano, Chile, 1988.

SECTION V (Farms)

26. U.S. Embassy, Santiago, April 23, 1986.

27. Apparently the trials were discontinued with high chlorine levels killed the stocked population. Julio Luna, personal communications, December 31, 1990.

APPENDICES

Appendix A.--Chile. Addresses

Research Groups

CORFO
Moneda 921
Santiago
CHILE

Fundacion Chile
Casilla 773
Via Sur
Parque Institutional 6651
Santiago, CHILE

Instituto Profesional de Iquique
Area de Ciencias del Mar
Laboratorio Huaiquique
Casilla 121
Iquique, CHILE

Instituto de Ciencias Biologicas
Pontificada Universidad Catolica de Chile
Casilla 114-D
Santiago
CHILE

IFOP
Casilla 1287
Santiago, CHILE

IFOP/Desideiro Garcia Sitio 2
Casilla 170
Iquique
CHILE

Instituto Profesional de Osorno
Dept. de Acuacultura
Casilla 933
Osorno, CHILE

Pontificada Universidad Catolica
Departamento de Biologia y Tecnologica del Mar
Casilla 127
Talcahuano, CHILE

Universidad de Antofagasta
Proyecto Cultivo de Crutaceo
Facultad de Recursos del Mar
Casilla 1240
Antofagasta, CHILE

Universidad de Antofagasta
Groupo de Acuicultura/Biologia Marina
Antofagasta
CHILE

Universidad Arturo Prat
Departamento Ciencias del Mar
Avenida 11 de Septiembre 2120
Iquique, CHILE

Universidad Austral de Chile
Centro de Investigaciones Marinas
Casilla 567
Valdivia
CHILE

Universidad Catolica del Norte/Centro Coquimbo
Facultad de Ciencias del Mar/Depto. de Acuicultura
Casilla 117
Coquimbo, CHILE

Universidad Catolica de Valparaiso
Escuela de Ciencias del Mar
Casilla 1020
Valparaiso
CHILE

Universidad de Chile
Facultad de Ciencias
Las Palmeras 3425
Ñuñoa, Santiago, CHILE

Universidad de Concepción
Departamento de Botánica
Casilla 2407
Concepción, CHILE

Projecto Manzanar/Groupo Acuicultura
Universidad Arturo Prat
Iquique
CHILE

Universidad de Chile
Departamento de Biologia
Casilla 147
Santiago
CHILE

Universidad de Chile
Oceanografia Biologica
Casilla 747
Arica
CHILE

Universiad de Concepcion
Instituto de Biologia
Casilla 1367
CHILE

Universidad del Norte
Dept. de Pesquerias
Casilla 1280
Antofagasta
CHILE

Universidad del Norte
Centro de Investigaciones Marinas
Casilla 75
Iquique
CHILE

Universidad de Tarapaca
Dept. de Oceanologia
Casilla 747
Arica
CHILE

Universidad de Valparaiso
Instituto de Oceanologia
Casilla 13-D
Viña del Mar
CHILE

Companies

Pesquera Indo, S.A.
Research Dept.
Huefanos 863 (3P)
Santiago, CHILE

Government Agency

Direccion Nacional de Acuilcultura
Servico Nacional de Pesca
Ministerio de Economia, Fomento, y
Reconstruccion
Bellavista 168, piso 16
Valparaiso, Chile

4.5

COLOMBIA

Colombia has emerged as a major Latin American producer of cultured shrimp. Although harvests are still small by world standards, current trends suggest that the country will become an important world producer during the 1990s. The industry's expansion has occurred in only a few years. Colombia had no commercial shrimp culture operations as recently as 1983. The earliest growers encountered serious difficulties, primarily because they simply attempted to transfer Ecuadorean designs and growout systems. The results were disastrous and some observers began to doubt the feasibility of culturing shrimp in Colombia.

Growers eventually concluded that they would have to adapt culture methods to Colombian conditions. Despite the initial problems, many investors have entered the industry aggressively, assisted by a well-conceived Government program to promote new export industries and critical assistance from foreign (mostly United States) consultants. While Colombian growers appear to have access to only small quantities of wild postlarval seedstock, they benefit from some of the most favorable growing conditions in Latin America. Colombia is the only Latin American country to develop a successful shrimp culture industry along the Caribbean/Atlantic coast. Conditions are best along the Caribbean coast, but impressive results are also being achieved along the Pacific. Colombian growers claim that their late entry into the world shrimp culture industry has allowed them to learn from the mistakes made in other countries and that they have been able to draw from the substantial and growing body of technical information available. Growers claim yields which are in many cases two or three times higher than those reported in Ecuador and many other Latin American countries.

Colombian companies have reported considerable success in solving one of their principal problems, the supply of postlarval seedstock. The first growers assumed that they would be able to collect pl in the wild as easily as it was possible to do in Ecuador. This did not prove to be the case. Growers experienced considerable difficulties and some farms failed as a result of the ensuing shortages. Colombia has now developed a hatchery industry which is capable of supplying the industry's current seedstock requirements. Colombian hatcheries, however, are heavily dependent on foreign hatcheries to supply nauplii. It will be several years before Colombian hatcheries will be able to free themselves from foreign suppliers and natural climatic cycles.

The results achieved through 1990 have been impressive. From only minimal harvests in 1985, growers reportedly harvested 6,000 metric tons in 1990 and exported over $30 million worth of cultured shrimp. Industry sources project that 1991 harvests may approach 10,000 tons and exports exceed $50 million. Growers not only ship to the large U.S. market, but have reported great success in entering the expanding European market. Further major increases in harvests and exports will almost certainly be achieved during the 1990s. Based upon current trends and available area, Colombian growers may be able to harvest about 30,000 tons by the year 2000 and more optimistic projections suggest that even larger harvests are possible. While such projections are only speculative at this stage, many observers are extremely optimistic about the industry's future and are convinced that Colombia will emerge as a major world producer, surpassed only by Ecuador in Latin America. Growers must resolve a variety of serious difficulties, however, if they are to achieve the optimistic projections. Some observers are especially concerned over the supply and quality of feed. Others worry about the industry's heavy debt burden. Some other major concerns currently include research, training, disease, postlarval seedstock, credit shortages, and Government economic policy.

CONTENTS

I. CAPTURE FISHERY

Colombia has only a small fishing industry, despite extensive Pacific and Caribbean grounds with important stocks which could support commercial fisheries. The Colombian fishing industry is the smallest of all the major South American countries. Fishermen only utilize a fraction of available stocks and the industry makes just a small contribution to the national economy. Most of the country's catch is taken by artisanal fishermen, primarily in inland waters. Officials are interested, however, in developing a modern commercial fishing industry. The Colombian Congress in 1990 passed a new basic fisheries law designed to promote both commercial fisheries and aquaculture.[1]

The shrimp fishery has for years been Colombia's only significant commercial fishery.[2] Shrimp trawlers have accounted for about 80 percent of the country's commercial fishing vessels. The fishery is conducted along both the Pacific and Caribbean coasts. Catches have fluctuated sharply from year to year, varying from 8,000 metric tons (t)[3] (1984) to 3,700 t (1979) (appendix B1). Yields have declined from those reported in the 1970s, especially along the Caribbean coast. One observer suggests that Caribbean fishermen are reporting catches of less than 2 t per trip compared to 5-9 t per trip 10 years ago.[4] Pacific coast fishermen have not reported as sharp declines. In addition, a substantial number of foreign trawlers participate in the Pacific fishery. Fishermen along both coasts report that their earnings have been impaired by the declining yields and substantial fuel price increases.

The Pacific shrimp fishery formerly dominated the industry (figure 1). Pacific fishermen still catch substantially larger quantities, but Caribbean fishermen now catch more of the high-value *Penaeid* species.

Caribbean fishery: Caribbean fishermen developed a shrimp trawl fishery during the 1960s.[5] The Instituto Nacional de los Recursos Naturales Renovables y del Ambiente (INDERENA)[6] reported that about 80 trawlers were active in the Caribbean fishery during 1989.[7] The 1989 catch totaled 2,000 t, down from the record 2,700 t reported in 1984 (appendix B1 and figure 1). The trawlers used in the fishery are 22-26 meters (m) long and average about 130 tons. The principal port is Cartagena (map 1A). Fishing

Map 1A.--Map of Colombia.

Map 1B.--Map of Colombia showing provincial boundaries.

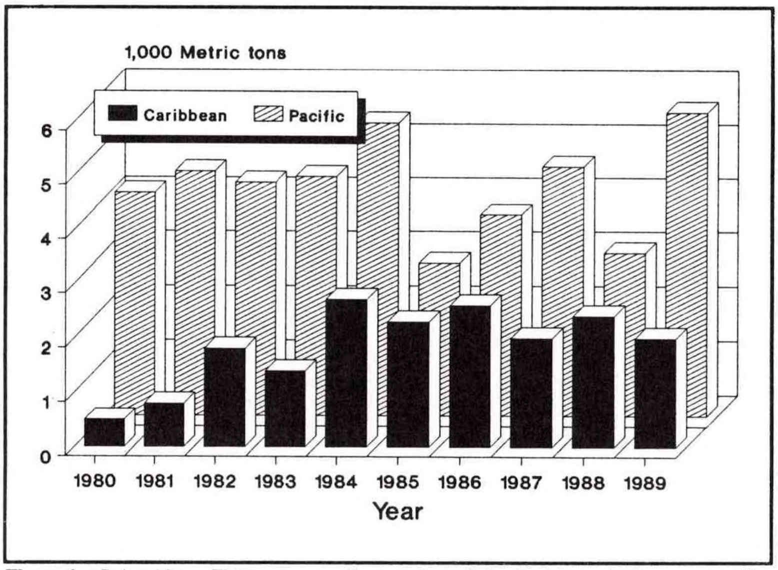

Figure 1.--Colombia. Fishermen conduct shrimp fisheries along both coasts. The Caribbean fishery is the smallest, but is composed mostly of high-value Penaeids.

operations are conducted year-round and the annual effort in 1989 was 17,685 fishing days.[8] About 90 percent of the fleet uses two trawl twin rigs (four trawls). Fishing is primarily conducted at night. INDERENA estimates that 80 percent of the fleet operates at night and that an additional 20 percent conducts at least some night operations. The Caribbean fishery is important because the catch is almost exclusively *Penaeid* species (appendix B1 and figure 1). (See: "III. Species.") Hijacking of shrimp trawlers has caused problems in past years, but a 1988 report suggested that the problem has declined.

Pacific fishery: Fishermen initiated a shrimp trawl fishery, the country's first commercial fishery, along the Pacific coast during the 1950s.[9] Pacific catches have varied from 5,700 t (1978) to 2,800 t (1985) (appendix B1). Yields have declined somewhat from those reported in the 1970s. One Colombian expert believes that the El Niño events in the 1980s and the expanding use of gillnets by artisanal fishermen are the primary reason for the decline.[10] The trawler fishermen primarily operate from Buenaventura, Tumaco, and Guapi (map 1A). The trawlers used in the Pacific fishery are similar to those used by Caribbean-coast fishermen. Most fishing (90 percent) is conducted in shallow waters from Cabo Manglares (Ecuadorean border) north to Cabo Corrientes. The remaining effort takes place in deeper water further north. The fishermen operate in the shallow waters only during the day. Deepwater fishermen operate both during the day and at night year-round. Normally fishermen will conduct four tows of about 3 hours each during the day and two tows of 5 hours each at night.[11]

Colombian fishermen accounted for virtually all of the country's shrimp production until 1988 (figure 2). The capture fishery is rapidly being replaced in importance, however, by a rapidly expanding shrimp culture industry. Growers probably harvested about half of the shrimp produced in 1990 and will almost certainly harvest more than half in 1991 (appendix C1). The capture fishery by the year 2000 will probably only supply a small portion of Colombia's overall shrimp production.

II. AQUACULTURE INDUSTRY

Colombia has one of the greatest potentials in Latin America for culturing aquatic organisms. The country's size, substantial freshwater resources (extensive network of lakes and rivers), important coastal estuaries, range of climates, coasts on two oceans, and other factors combine to create a very

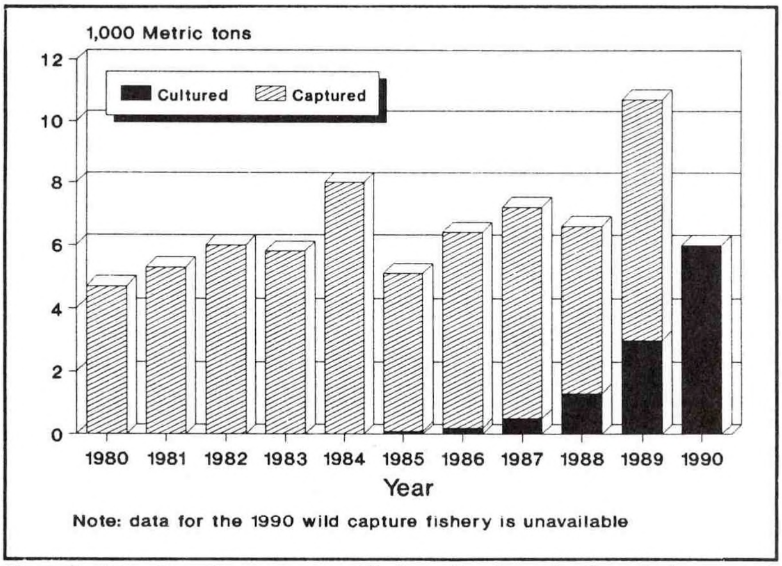

Figure 2.--Colombia. Growers are rapidly becoming the major force in the country's shrimp industry.

substantial potential for developing a major, diversified industry. Despite this potential, the country has only developed a very small aquaculture industry.

Colombian **aquaculture** was initiated with freshwater species. The first species cultured commercially was rainbow trout, which was introduced in 1939, primarily to stock rivers and lakes. During the 1940s and 1950s, other groups introduced carp and tilapia for the first pond growout operations. Government research institutes began working with various indigenous species, especially bocachico, during the 1960s. Subsequently Colombian institutes have reported work on mullet, dorado, and cachama. Colombian groups did not begin serious work on **mariculture** until the 1980s. While this effort has focused on shrimp culture, some work has also been done on pampano, snapper, oysters, mussels, crab, seaweed, and other species.[12]

The Government initiated various efforts during the 1970s and 1980s to promote an aquaculture industry. The Instituto de Fomento Nacional (IFN) included an aquaculture component in its 1979-82 "Plan de Integracion Nacional." This initial effort was continued by INDERENA and the various regional development corporations.[13] The Government announced a national aquaculture plan in 1986 as part of an overall effort to expand the fishing industry.[14]

The major pond harvests in 1989 were reported for shrimp, tilapia (1,000 t), trout (800 t), cachama (800 t), and a variety of other species.[15] All of these species, except shrimp, account for only 1,000 t or less annually. The only significant commercial operations are for marine shrimp. Some of the shrimp farmers, however, are reporting successful results with a polyculture system developed in Israel for combining shrimp and tilapia growout operations. (See: "VIII. Methods.") As a result, the 1991 tilapia harvest has now probably exceeded the 1,000 t level.

III. SPECIES

Colombian shrimp fishermen report catches of a wide variety of different species because they conduct fishing operations in both the Caribbean and Pacific.[16] **Caribbean** fishermen catch primarily *Penaeid* species (*Penaeus notialis, P. schmitti, P. subtilis*, and *P. brasiliensis*) as well as small quantities of low-value seabobs/"titi" (*Xiphopenaeus kroyeri*).[17] **Pacific** fishermen catch large quantities of several small non-*Penaeid* species, primarily seabobs (*X. kroyeri riveti*) and Carabali/"tigre" (*Trachypenaeus byrdi*) shrimp. Smaller quantities of *Penaeid* species (*P. occidentalis, P. vannamei*, and *P. stylirostris*) are also taken.[18]

Colombian growers have concentrated on one marine species, although research and trials have been conducted on several indigenous species.

A. Marine

Colombian growers almost exclusively culture white shrimp, especially *P. vannamei*. Growers have conducted trial runs, however, with numerous species. Much of the early experimentation with alternative species was relatively informal studies. The growing sophistication of the Colombian farms suggests that many companies are now compiling relatively detailed internal data bases on growout performance, especially of *P. vannamei*. Colombian academic groups have published relatively few studies, but some work has been carried out on most of the important indigenous species.[19] (See: "XVIII. Technical Capability: Research.") Both growers and researchers confirm the superior performance of *P. vannamei*.[20]

P. vannamei: Pacific whiteleg shrimp is the principal species used for culture in most Latin American countries. Of all the Latin American species, *P. vannamei* seems to adapt the best to estuarine conditions. Juveniles tolerate the sharp swings of salinity, temperature, pH, and dissolved oxygen levels which often occur in estuaries, giving it the reputation of a "tough species." Colombian researchers, especially at INDERENA, have focused much of their effort on this species.[21] Experimental runs showed it to be a highly aggressive species which consumed a wide range of plant and animal matter, including other species of shrimp.[22] The species is preferred by virtually all Colombian growers on both the Pacific and Caribbean coast. One observer estimates that about 90 percent of Colombia's cultured harvest is *P. vannamei*.[23] Colombian researchers have given particular attention to the possibility of using *P. vannamei* along the Caribbean coast.[24] Some Colombian authors have also devoted considerable attention to the possibility of culturing *P. vannamei* in freshwater.[25] *P. vannamei* seedstock is mostly obtained from domestic, Ecuadorean, and Panamanian hatcheries. Small additional amounts of *P. vannamei* postlarvae (pl), along with *P. stylirostris* and *P. occidentalis*, are reportedly collected around Tumaco. Although *P. vannamei* occurs in Colombian waters, it is apparently more difficult to collect than in either Ecuador or Panama and few farms can rely on postlarval seedstock collected in the wild. (See: "XI. Postlarval Supply: Wild collection.")

P. stylirostris: Colombian growers culture small quantities of blue shrimp, another Pacific-coast white shrimp. Production probably does not exceed 5-10 percent of the total harvest. *P. stylirostris* is mostly used in polyculture with *P. vannamei*.[26] Observers report that a substantial supply of *P. stylirostris* pl may be available in Pacific coast estuaries, although, no one has yet succeed in collecting large quantities for sale to local growers.[27]No known Colombian grower has expressed a preference for this species, but Colombian researchers have devoted some attention to it. Many report that *P. stylirostris* is more difficult than *P. vannamei* to culture, requires higher quality feeds,[28] and is somewhat more difficult to market abroad.[29] Other assessments are more optimistic. One observer reports that successful *P. stylirostris* trials using extensive methods have been conducted in Colombia.[30]Another observer says that most growers would like to include at least some *P. stylirostris* if they could obtain a regular supply of postlarvae.[31]

P. schmitti: Southern white shrimp was the first species used by Caribbean growers, primarily because pl was locally available.[32] Industry groups were initially optimistic about the culture potential.[33] Some limited research in Colombia has been conducted on this species.[34] Despite the early optimism, however, growers have achieved only disappointing yields. Some growers reported acceptable survival rates, but disappointing yields.[35] Much of the limited research conducted by Colombian researchers has focused on survival and nutritional problems.[36] One observer reports that growers have achieved profitable yields with *P. schmitti*, but have generally rejected it because yields with *P. vannamei* are so much higher.[37] Other researchers have worked on pl production.[38] No growers are know to be using *P. schmitti* during 1991.[39] While results with *P. schmitti* have been far below those obtained with *P. vannamei*, it does appear to be the best performing indigenous Caribbean-coast species.[40] As a result Colombian researchers are continuing their work on this species.[41]

P. occidentalis: A few Pacific growers have experimented with western white shrimp, but results have been extremely poor. Incidental results by growers also suggest that this species is not well-suited for culture. Varying quantities of *P. occidentalis* pl are present in wild collected pl and in the water circulated through the ponds. Even so, harvests of ponds stocked with wild pl rarely contain significant quantities of this species. In fact, growers attempting to use wild-collected pl often try to kill the *P. occidentalis* before stocking their growout ponds.

Other marine species: INDERENA reports that various Colombian groups have reported laboratory work and trial growout runs with other species, including *P. aztecus, P. brasiliensis*[42], *P. d. duorarum*,[43] *P. d. notialis*[44], and *P. subtilis*[45]. Growers have also conducted a variety of mostly informal trials. Details on these trials are largely unavailable, but generally confirm the superior performance of *P. vannamei*. As a result, most growers have decided to use *P. vannamei*.

B. Freshwater

Several species of freshwater shrimp are indigenous to Colombia. One researcher reports that five species occur along the northern coast.[46] Various Colombian groups have worked with some of the indigenous species as well as imported exotics.[47] (See: "XVIII. Technical Capability.") The Colombian effort to evaluate these species has been aided by a Taiwan technical assistance program.

Macrobrachium sp.: Some limited research efforts have assessed various indigenous freshwater shrimp, especially *Macrobrachium acanthurus*[48] and *M. carcinus*.[49] Researchers have conducted some trial runs.[50] These trials, however, have yielded largely negative results as a result of aggressive behavior and other problems.

Macrobrachium rosenbergii: Most researchers believe that freshwater operations will have to use the exotic species commonly employed elsewhere in Latin America, *M. rosenbergii*. Colombian researchers with considerable assistance from the Taiwan technical assistance mission have generally focused on *M. rosenbergii*.[51] INDERENA has promoted the utilization of the species, especially in the Cauca Valley area (map 1B).[52] One group organized a seminar in 1989 focusing on freshwater shrimp culture.[53] Available reports suggest that some progress is being made in resolving technical problems and that commercial growout operations are increasingly possible.[54]

Other species: Colombian researchers have also expressed an interest in other species. One group, for example, has conducted some preliminary work with Louisiana crawfish (*Procambarus clarkii*).[55]

C. Artemia

Artemia is an important food source for larval shrimp and thus needed by Colombia's expanding hatchery industry. Most hatcheries import *Artemia*, but it may be possible to produce supplies locally. Small amounts of *Artemia* are already produced in Colombia, utilizing Caribbean coast salt evaporation ponds, and several observers report that production could be significantly expanded. Some observers believe that Colombian *Artemia* producers have the potential of fully supplying the country's hatcheries.[56]

Galezamba: Operations at Galezamba, Bolívar Department (map 1B) utilize 165 hectares (ha) of ponds for biomass production and 9 ha for cyst production. Harvests totaled 9.0 t in 1987, including 0.8 t of cysts. Pond operators hope to increase production to 50 tons.

Manuare: A much larger area of salt ponds exists at Manuare, Guajira Department (map 1B), but production there is still experimental, totaling 0.2 t of cysts in 1987.[57] A recent report suggests that nearly 1,000 ha of ponds are suitable for cyst production. One expert estimates monthly yields at 5 kg of cysts per ha, or about 60 t of cysts per year.[58] Estimates suggest that 1,100 ha are suitable for biomass production and monthly harvests could reach 0.1 t per ha or nearly 1,300 t per year.[59]

IV. AREA/LOCATION

No detailed survey has been conducted to determine the precise area suitable for pond construction in Colombia. Experts vary widely on the potential area, but it is clearly substantial. Most experts, but not all, maintain that the potential area along the Pacific coast is greater than along the Caribbean. An estimate prepared by the growers suggests that a total of about 23,000 ha of ponds could be built; divided along the Pacific (9,000 ha) and the Caribbean (14,000 ha) coasts.[60] Other observers suggest that the potential, especially along the Pacific, is much higher.[61] Two sources estimated that at least 40,000 ha of ponds could be built. Other estimates approach 60,000 hectares. The Regional Aquaculture Network estimate suggests that 39,000 ha of ponds could possibly be built along the Pacific coast alone.[62] Cenipacífico estimates that nearly 40,000 ha are suitable along the Pacific, confirming the Regional Aquaculture Network estimate.[63] Another observer estimates potential sites total about 55,000 ha along the Pacific (35,000 ha) and Caribbean (20,000 ha).[64]

The wide range of estimates of the potential area is due to the complexity of assessing sites, the inaccessibility of many areas, and the limited available data. The suitability of sites is determined by a complex set of climatic, physical, and hydrological factors.[65] Economic factors must also be considered in assessing potential farms. Thus sites which may prove suitable at current shrimp prices, may not yield profitable results if shrimp prices fall. Likewise, if shrimp prices rise, it may be possible to develop marginal sites. More accurate data on potential sites may be available in the future. The European Community is preparing a program to identify potential sites in the Tumaco area by using satellite imagery.[66] If this effort proves successful, similar studies could be conducted in other areas. While the precise area is still at issue, most observers concur that a substantial area of suitable sites is available. Colombia clearly has the potential to substantially expand pond area during the 1990s.

Growers are currently operating in a small number of locations along the two coasts. Most growers have selected coastal sites close to mangrove areas. Generally salt flats with little vegetation are preferred. Proper pond management requires that sources of both fresh and sea water need to be

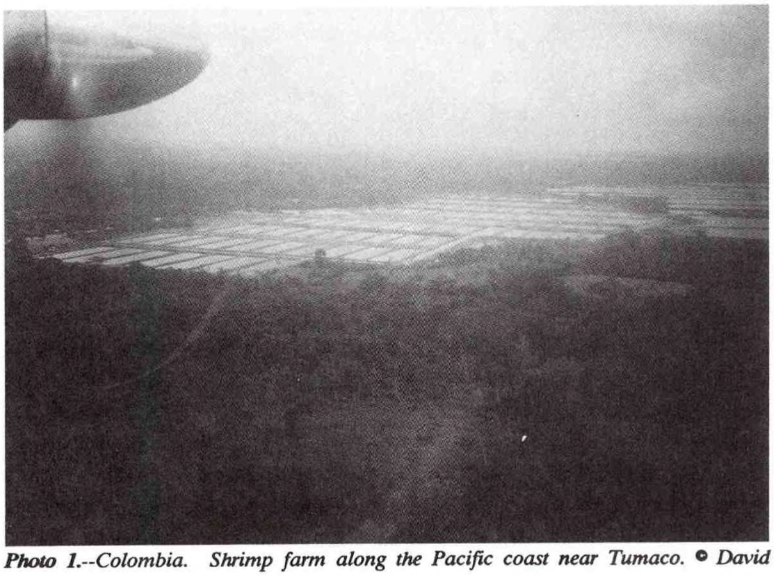

Photo 1.--Colombia. Shrimp farm along the Pacific coast near Tumaco. © *David Larson*

available.[67]

Caribbean growers are currently located at the Golfo de Urabá, Golfo de Morrosquillo, Bahía de Barbacoas, Ciénaga Grande de Santa Marta, and Ensenada de Amansaguapos. Growers are also considering sites further east at more isolated sites along the la Guajira Peninsula (map 1B).

Pacific coast growers are currently all clustered in the Tumaco area (map 1B), which is located in southern Colombia near the Ecuadorean border.

Growers have reported different experiences along the country's two coasts. Some of these differences affecting the suitability and economic viability of projects include:

Growing conditions: A variety of climatic and physical conditions are reported along the two coasts. Most observers believe that climatic and physical conditions tend to favor the Caribbean coast sites. (See: "V. Growing Conditions.") One observer reports that Caribbean growers have been more aggressive in adapting growout methods to local conditions and more willing to contract foreign consulting groups for technical assistance than Pacific-coast growers.[68]

Infrastructure: One major factor assisting Caribbean growers is the more developed Caribbean-coast infrastructure. In addition, Caribbean companies can locate their offices at Cartagena, close to their farms. A major factor impeding the development of the industry along the Pacific coast is the less developed infrastructure available there. Pacific coast companies have generally decided against locating their offices in Tumaco because of the limited facilities there. Many have located in Cali, Medellín, or even Bogotá, complicating farm management. Some progress has been made in correcting the situation. Tumaco has been connected to the country's power grid and some highway construction has taken place, improving access to the interior. Many problems, however, still exist.[69] Only three packing plants are located in Tumaco[70], compared to four in Buenaventura (map 1A), the country's principal port, where a shrimp trawl fleet is based. (See: "XIV. Processing.") Processors cannot export their shrimp directly from Tumaco, but instead have to ship it to Buenaventura, escalating costs. Colombian feed mills are located at considerable distance from Tumaco and transportation charges substantially increase costs.[71] Caribbean growers, on the other hand, have access to a mill located in Cartagena (map 1A) and two more are reportedly planned for completion in 1991-92.[72] (See: "X. Feed.")

Hatcheries: Only four Pacific Coast hatcheries were regularly operating in 1991, compared to nearly 20 hatcheries along the Caribbean coast (appendix H1). The Pacific growers, however, are located close to hatcheries and pl collectors in northern Ecuador, which are an important source of seedstock for them. (See: "XI. Postlarval Supply: Seedstock imports.")

Land costs: Pacific coast growers benefit from generally lower land prices.

Colombian growers have been steadily expanding pond area. ACUANAL reports that the area of ponds has increased from only 400 ha in 1985 to nearly 3,800 ha by the end of 1990 (appendix D1 and figure 3).[73] A more accurate estimate might be the pond area in operation which probably totaled about 2,500 ha in 1990 (appendix D1 and figure 3).[74] Overall investments as of 1990 totaled about $45 million.[75] Most growers have substantially expanded their operations as a result of the excellent results they have achieved. Nearly 800 ha of new ponds were constructed in 1990 alone.

Construction of new ponds appears to be continuing at a fairly stable rate (appendix D2 and figure 3). New pond construction will total less than 300 ha in 1991 and about 400 ha in 1992. The reasons that growers have not accelerated pond construction are unclear, but probably reflect the heavy indebtedness at many farms, rising costs in developing isolated sites, and the more costly designs at the increasingly sophisticated semi-intensive farms. ACUANAL reports that pond area statistics can be

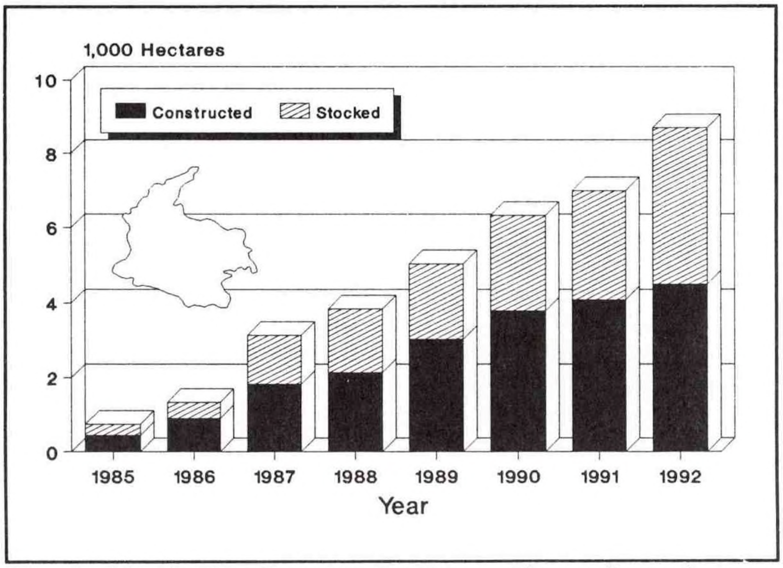

Figure 3.--Colombia. Colombian growers have been steadily expanding pond area.

confusing. ACUANAL officials say that some of the less technically sophisticated growers are closing operations, but the more technically competent, well financed operations are continuing to expand pond area.[76] A U.S. businessman who visited Colombia in May 1991 reports considerable optimism among major companies and continued pond construction.[77] The total area of Colombian ponds by the end of 1991 will probably exceed 4,000 ha with nearly 3,000 ha in operation (appendices D1, F, and G3).[78]

Future projections on pond construction are extremely difficult to make at this time. Some observers are optimistically projecting that as many as 20,000 ha of ponds may be in operation by 2000, but this would necessitate a major pond construction boom. Given the substantial problems described in this chapter, new pond construction rates in the 1990s are unlikely to exceed those reported during the 1980s. As a result, more conservative projections suggest that growers may have only about 6,000-7,000 ha of ponds in production by the year 2000.

Colombian growers face major difficulties in utilizing many suitable sites. Some otherwise excellent sites cannot currently be developed because of their isolated location. In many cases sites are not accessible from existing roads and most public services such as electrical lines are not available.[79] Construction of the necessary infrastructure in many cases in prohibitively expensive for growers and in other cases has been attempted, but has significantly increased farm start-up costs. This is an especially serious problem along the lightly settled Pacific coast. Whereas Caribbean-coast sites are located close to Cartagena and other attractive areas, living conditions in Tumaco are much less inviting. Conditions in other Pacific coast areas offering suitable conditions are even less appealing. Investors will have considerable difficulty attracting competent technical staff to work in such isolated locations. Other growers are reportedly attempting to develop sites with less than ideal conditions, but in many cases this will require expensive design features and result in higher operating costs. ACUANAL reports that many companies are reporting rising indebtedness,[80] probably due, at least in part, to cost overruns on farm construction. Several farms report that construction programs have overrun projections.

Growers have reported fluctuations in pond utilization. In some years, such as 1986, only about half of the ponds were stocked. The reasons for the low rate vary. In some cases the owners have abandoned their ponds because of inadequate financing, faulty design, poor management, or other problems. In some years the shortage and high cost of pl was the major problem. Despite such sharp fluctuations, many growers insist that they are gradually improving utilization rates. Several growers point out that construction and redesign projects temporarily depressed utilization rates.[81] This has been particularly true during 1989-91 as many farms completed construction projects. In recent years the utilization rate has been about 65-70 percent (appendix D1). Growers in 1990, for example, reportedly stocked about 2,600 ha of ponds out of the 3,800 ha of constructed ponds, about 65 percent. Many growers are anticipating, however, sharply increased utilization rates in 1992 (appendix D1). Growers are hoping that by 1992 their new ponds will be fully operational and increasing pl supplies will permit full stocking.

V. GROWING CONDITIONS

Colombia has one of the longest coastlines in Latin America suitable for shrimp culture.[82] The country has nearly 3,000 kilometers (km) of tropical coast, along both the Caribbean and Pacific. The Caribbean coast (1,600 km) is somewhat longer than

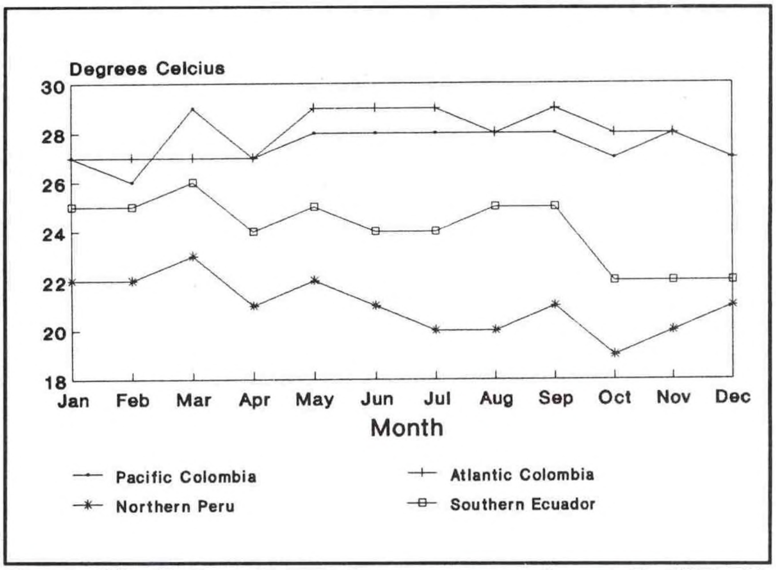

Figure 4.--Colombia. Sea surface temperatures are warmer and more stable off Colombia than most other Latin American countries (1990 data).

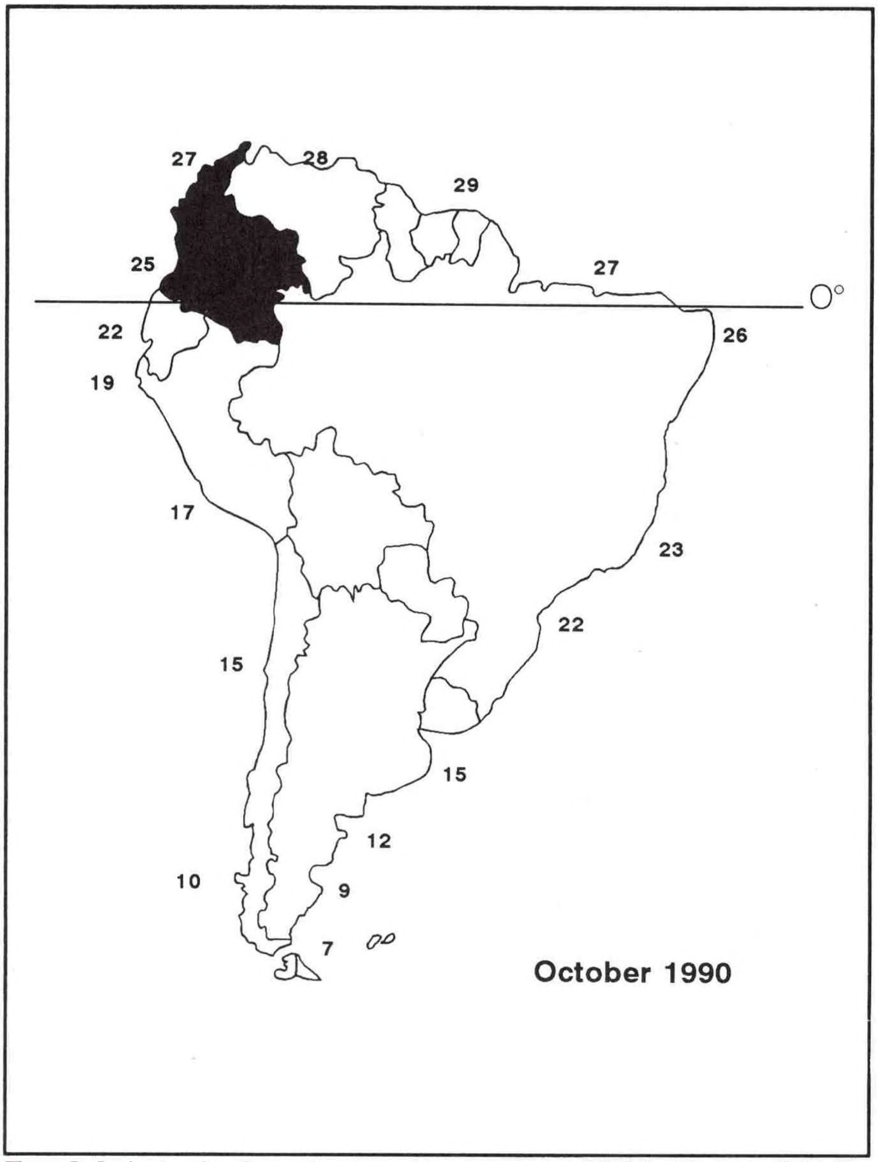

Figure 5.--Latin America. Sea surface temperatures are warmer off Colombia than off Ecuador where the region's shrimp culture industry is currently centered.

the Pacific coast (1,400 km) (map 1A).

A. Factors

Colombian growers report extremely favorable growing conditions. Some observers are convinced that even though wild pl is scarce, growing conditions at many Colombian sites are more favorable than in neighboring Ecuador,[83] the current center of Latin America's shrimp culture industry. Various observers believe Colombian growing conditions permit better results than can be achieved in Ecuador.[84]

Temperature is a major advantage to Colombian growers, especially along the Caribbean coast. Colombian growers, for example, are less subject to the sharp temperature fluctuations that can impair Ecuadorean operations (appendix E and figure 4). Ecuadorean farmers are located on the southern limit of the natural range of tropical shrimp, especially *P. vannamei* and harvests can be significantly impaired by only a small temperature decline. Average sea surface temperatures tend to be warmer and more stable off Colombia (especially along the Caribbean coast) than off Ecuador (appendix E and figure 4 and 5). Sea surface temperatures along the Caribbean coast are stable at 27-29° C almost all of the year and are usually 1-2° C higher than along the Pacific coast (appendix E).

Precipitation and photoperiod are also highly favorable, especially along the Caribbean coast. The Caribbean rainy season (May-November) is much more moderate than along the Pacific coast. Caribbean precipitation seldom exceeds 15 centimeters (cm) per month. Along the Pacific coast there are extended periods of heavy rainfall and limited sunlight.[85] Rainfall can exceed 50 cm per month during the rainy season (January-June).

Water quality is another advantage enjoyed by Colombian growers. Colombia has significant freshwater resources. Various industry sources claim that Colombia has "pollution free" water enabling growers to produce a superior product.[86] Hard data on water quality, however, is not available to confirm this claim. Along the **Caribbean**, the Magdalena River which drains the country's central valley and feeds into the Caribbean near Baranquilla is the most important river system flowing into the Caribbean. Rising pollution levels from agricultural, municipal, industrial, and mineral (including petroleum) activities have been noted.[87] While not yet a serious problem, some observers have expressed concern over water quality along the Caribbean coast, especially reports of declining water quality in Cartagena Bay.[88] Along the **Pacific**, given the fact that Pacific coast farms are located in lightly settled areas, the water available to the growers may well be some of the most pollution-free water used by Latin American growers. FAO notes, however, some local problems rising from municipal sewage and mining.[89] Specific details on the area around Tumaco, however, are not available. Little attention on either coast is currently being given to regulating pond effluent. Thus effluent currently is emptied into the estuaries from which other growers pump water.[90] This is more of a problem in Ecuador where huge expanses of ponds are clustered together, but will become an increasing problem in Colombia as growers expand pond area.

Photo 2.--Colombia. Growout ponds at a farm along the Caribbean coast. © David Larson

Habitat: The Pacific coast has extended areas of mangrove forestry. There are extensive mud flat estuaries with an average 3-m tidal range. One observer says that soils along the Pacific vary considerably, from loam to pure organic peat, but have little relationship to productivity.[91] Another observer notes that high ferrous oxide content in soils around Tumaco has given a slightly yellowish cast to harvested shrimp when compared to the greenish-grey cast of Ecuadorean harvests.[92] The Caribbean coast has less mangrove forestry[93] and is typically beach or bay habitat with tidal ranges averaging about 0.25 m with maximum tides of about 0.6 meters.

B. Coasts

Conditions vary significantly between the two coasts. Most observers believe that the best sites are located along the Caribbean coast. This is in sharp contrast to the experience in most other Latin American countries (Belize, Brazil, Costa Rica, Cuba, Honduras, Mexico, Panama, and Venezuela) where growers have had difficulties culturing shrimp along the Caribbean/Atlantic coast.

Caribbean: Growers report that conditions along the country's Caribbean coast are some of the most ideal in Latin America. Temperature and precipitation appear to be more favorable than along the Pacific coast (figure 4). The more moderate rainy season results in more stable salinities and, as a result, Caribbean growers are not as affected by the sharp swings in salinities with which Pacific-coast growers have to contend.[94] *P. vannamei* can tolerate wide swings in salinity, but it does affect growth rates. The relatively modest tidal amplitude in the Caribbean simplifies daily operations (pumping, water exchange, harvesting, transportation, etc.) at the farms.[95] These ideal Caribbean conditions are the primary factor enabling growers to achieve superior yields.[96] As a result, Caribbean growers report better and faster growth rates than achieved with comparable stocking densities in Pacific-coast ponds.[97] (See: "IX. Yields/Production Costs.")

Pacific: Pacific coast conditions are less favorable than along the Caribbean. Climatic conditions along the Pacific cause a variety of problems for growers. There are prolonged seasonal periods of lower temperature which retard growth (appendix E).[98] The duration of these cooler periods vary from year to year and are associated with the strength of the northerly flowing cold Humboldt Current. The heavy precipitation creates numerous problems for pond managers. Besides the sheer volume of water that managers must contend with, such heavy rains can have dramatic effects on salinities in coastal estuaries which the growers use as a source of water. This further complicates pond management.[99] The significant tidal amplitude along the Pacific coast creates a variety of problems for pond operators. Some observers report that soil conditions, at least in the Tumaco area, are not optimal.[100]

Inland: Colombia has a large potential area suitable for freshwater shrimp culture. The country's substantial freshwater resources suggest that significant quantities of freshwater shrimp could be cultured, although the rugged mountainous terrain limits available sites. Various Colombian studies provide detailed data on conditions in some areas.[101]

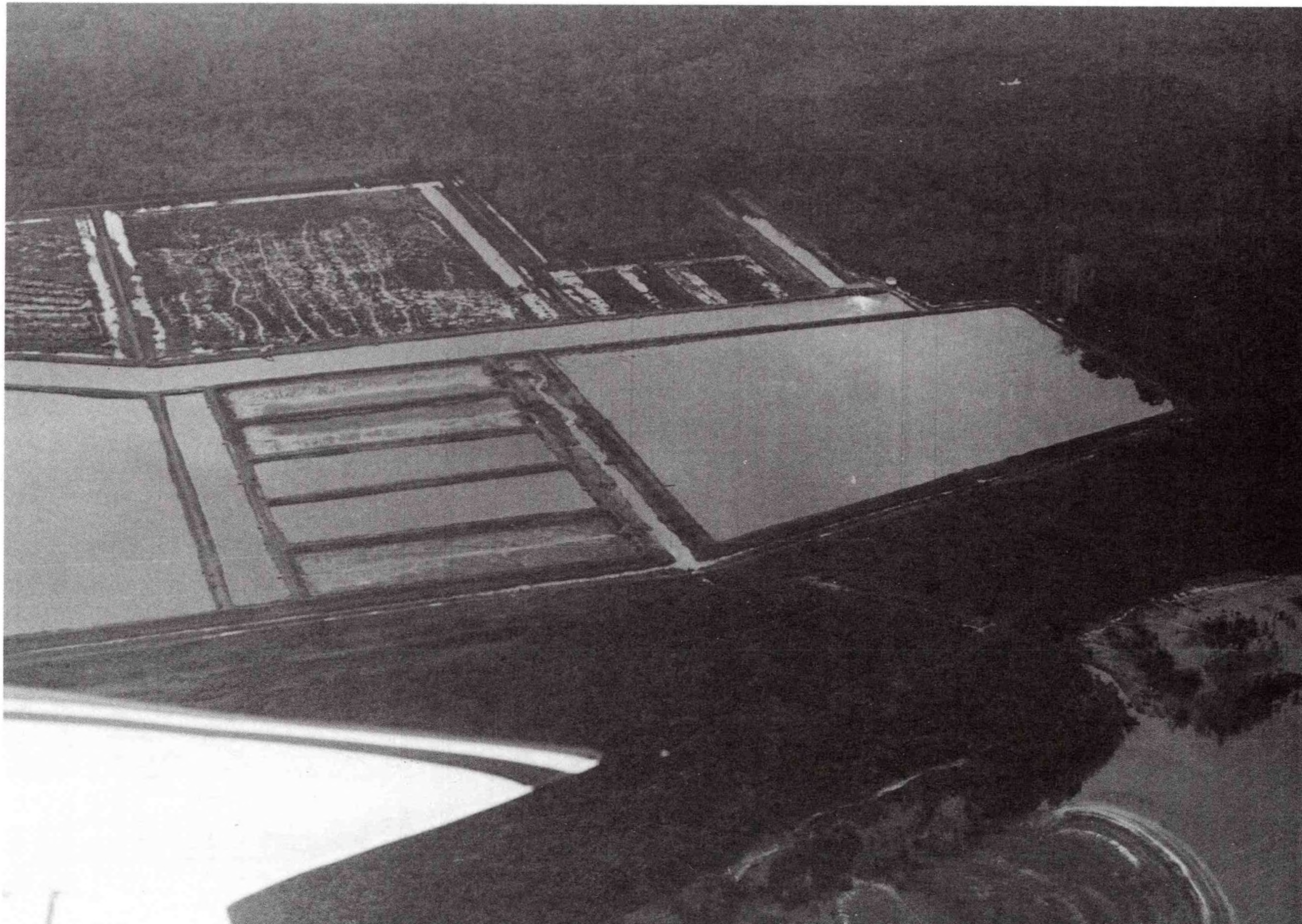

Photo 3.*--Colombia. Aerial view of a Pacific-coast farm. ©ACUANAL*

VI. ECONOMIC CONDITIONS

Various economic factors have proven advantageous for the development of the shrimp culture industry in Colombia. The country has a relatively developed **agricultural base**. Thus many of the support industries, such as feed companies, already exist to supply the needs of shrimp growers. The Colombian **Government's interest** in increasing export earnings made possible needed policy decisions to assist the industry's development. (See: "XVI. Government Role.") The interest of major **Colombian companies** and investment groups provided important financial support for the struggling new industry. Growers found a more **stable credit situation** in Colombia than in most other Latin American countries. The Colombian Government has pursued a more prudent foreign borrowing program than many other Latin American countries. In addition, foreign currency earnings from an expanding export economy is generating significant capital, considerably easing an otherwise tight credit situation.[102] Other favorable economic factors, such as **low wage rates** and relatively **inexpensive land costs,**[103] are similar to the overall Latin American situation.

Colombian investors face a variety of difficulties. Restrictive **investment** and **foreign exchange** regulations have discouraged investment, especially needed foreign investment. The restrictions are being addressed in the Government's Apertura Economic Program. (See: "XVII. Credit.") A variety of other economic problems, however, continue to face investors.[104] Growers report rising **debt loads** and many report increasing problems obtaining credit.[105] Major **infrastructure** improvement programs are needed, especially ports, roads, electricity lines, etc. The development of the Cartagena, Barranquilla, Santa Marta urban area (map 1A) has offered Caribbean coast growers real benefits in terms of the availability of basic infrastructure. Even so, growers expanding outside this area will encounter the basically primitive infrastructure existing in most other Caribbean-coast areas.[106] The situation along the Pacific coast is even worse. This is a particular problem limiting the development of Pacific-coast sites. The Government is privatizing the port system, but this may take 3-5 years. A major $300 million road improvement program has been postponed as funds originally targeted for roads have been required to repair infrastructure damage from increased guerilla activity. Colombia has an **image** problem in some foreign markets. Some importers avoid Colombian product due to fear of cocaine being smuggled in shipments and delays and costs associated with customs searches. The volatile **security** situation causes a variety of problems. The public order problem complicates road transport and insurance costs are increasing. The continuing violence also creates difficulties operating in remote rural areas, especially along the Caribbean coast. One farm reported an attack by a communist guerilla group. National Liberation Army (ELN) guerrillas attacked the Cartagenera farm during April 1989, causing over $100,000 in damage.[107] ACUANAL reports, however, that the incidents have been isolated and have not had a significant impact on the industry's development.[108] No further incidents have been reported in 1990 and 1991.

VII. COMPANIES

The Colombian shrimp culture industry is dominated by a relatively small number of companies which operate most of the country's ponds (figure 6).[109] Some of the companies are incorporated and the others are mostly limited partnerships. U.S. observers familiar with the industry tend to report a high degree of business and managerial expertise. The industry's early development was strongly aided by the involvement of important Colombian corporations (Bavaria[110]) and several major investment groups (Echeverry-Jaramillo and Martinez-Magaña).[111] Few of these early efforts, however, contracted knowledgeable technical specialists and many failed. Several small growers are also participating with limited areas of ponds, but are a relatively small element of the Colombian industry (appendix G3). The early investors were mostly replaced by a new generation of growers which was more willing to contract for technical assistance (often foreign) and who are rapidly gaining increasing experience and sophistication in operating modern shrimp farms. Some industry observers, however, continue to express concern with the heavy indebtedness.[112]

A. Marine farms

1. Caribbean coast

Caribbean growers in 1990 operated about 15 farms with a total pond area of 1,500 ha (2,000 ha constructed), primarily in the Cartagena area

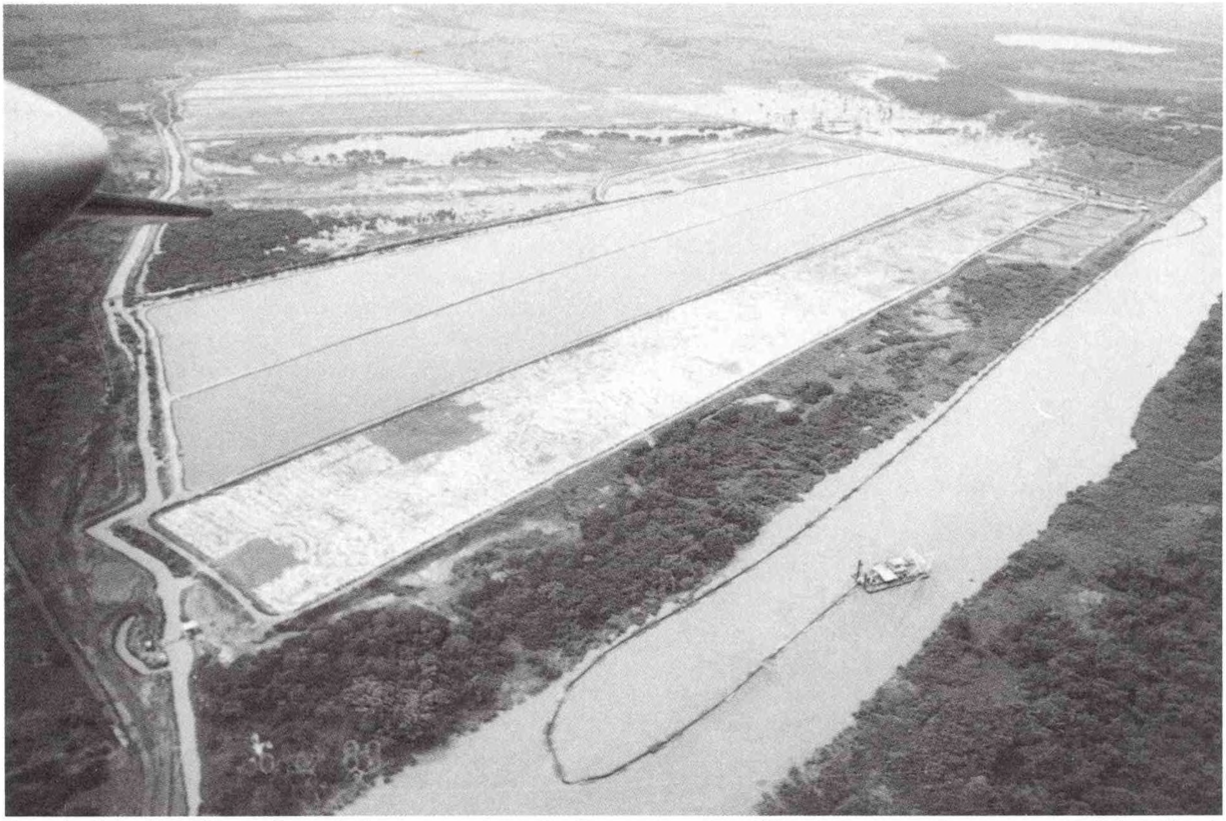

***Photo 4.**–Colombia. Using dredge spoils from a water channel to "improve" pond conditions in P. vannamei growout ponds.* © *Paul Maugle*

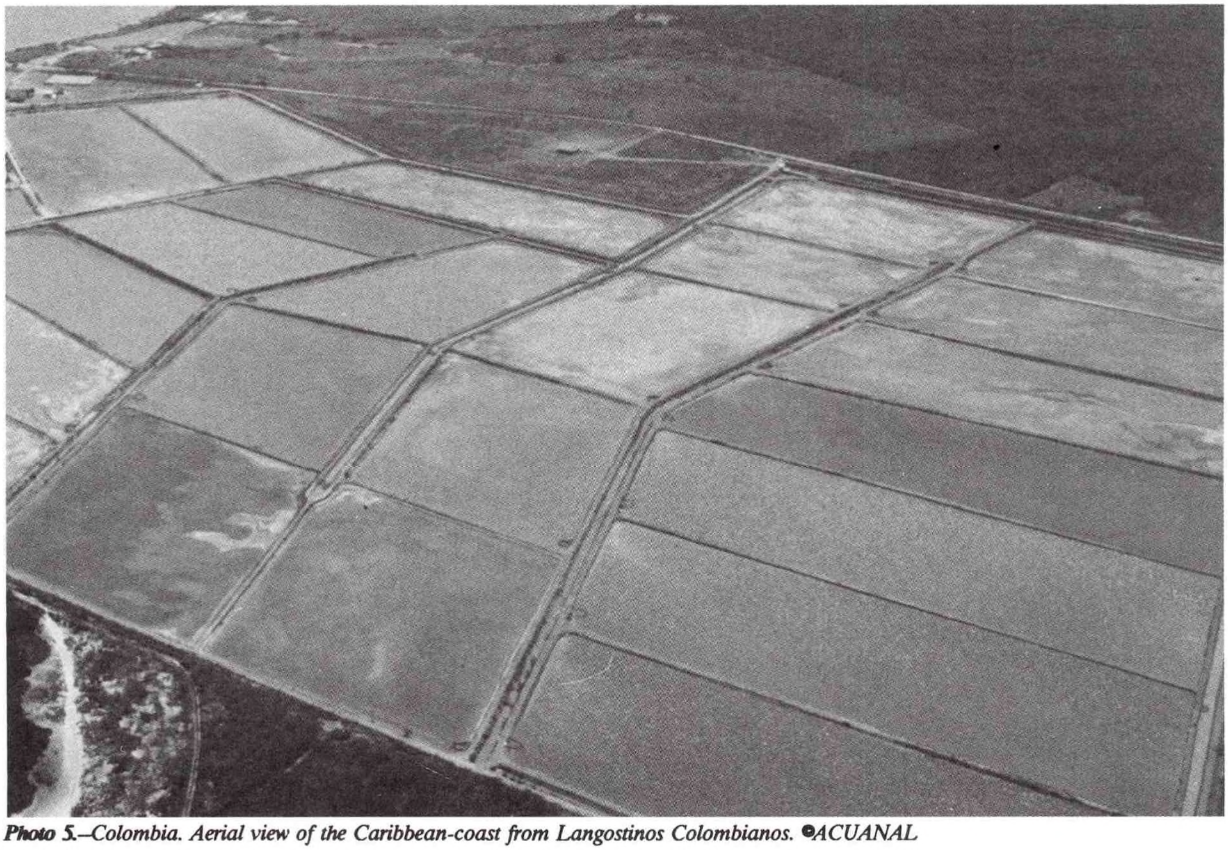

***Photo 5.**–Colombia. Aerial view of the Caribbean-coast from Langostinos Colombianos.* ©*ACUANAL*

(appendix F). The major Caribbean-coast companies are:

Aquacultivos del Caribe: The company is located at Galerzamba, Bahía de Amansaguapos. It is financed by a consortium with Bogota and Cali interests. The $1.2 million farm includes both growout ponds and a hatchery.[113] Initial results were disappointing. The company contracted a U.S. consulting firm, Tropical Mariculture Technology (TMT), which suggested major engineering changes to the original farm complex. The company implemented these changes and built a substantial number of new ponds in 1990. As a result, Aquacultivos is reporting substantially improved results. It is operating about 125 ha of ponds in 1991, little changed from 1990. The 1990 harvest approached 350 t and export revenue exceeded $1.8 million, massive increases over the limited 1989 results. Company officials project that 1991 results could nearly double those reported in 1990 because of fuller utilization of the new ponds.

Acuipesca: The company is located at the Bahía de Barbacoas. It is financed by the Mineros de Antioquia Group of Medellín. The company carried out a pond construction program in 1989 and 1990. Considerable progress was made during 1990 in improving pond utilization after implementing minor engineering changes suggested by TMT. The company operated about 190 ha of ponds in 1991. The 1990 harvest exceeded 615 t and export revenue nearly reached $3.4 million. Company officials project about a 10 percent harvest increase in 1991.[114]

Agrosoledad: The company is located at San Antero, Cordoba Department (map 1B). It completed a major pond construction program in 1990. The company contracted with TMT for technical assistance from the initial phases of the project. It is operating about 180 ha of ponds in 1991. The 1990 harvest totaled 500 t and exports amounted to $2.7 million. Company officials hope to improve pond utilization in 1991 and plan to harvest 700 t in 1991.[115] The company reported growout problems in some ponds during 1990, especially low dissolved oxygen levels and abnormally small shrimp.[116] Despite this problem, Agrosoledad has achieved some of the highest yields in the industry. The company reported a crop of 2.8 t per ha (without aeration).[117] It has a state of the art mechanized harvest system and excellent handling facilities. Agrosoledad has emphasized development of European markets under its "Canoa" brand, but has introduced two new brands in 1991, "Calule" and "Karindo." The company has given more attention to diversifying product line and developing value-added products than other Colombian farms. Product forms offered include frozen headon raw, headon cooked, peeled, and skewer shrimp. Agrosoledad is studying other markets and is especially optimistic with possible Middle Eastern sales.[118]

Camarones del Caribe (CAMCAR): The company is one of several Caribbean-coast farms which is operating about 200 ha of ponds in 1991. CamCar has been steadily adding small numbers of ponds. The 1990 harvest totaled 600 t and export revenue amounted to $3 million. The company expects that improved pond management will substantially increase 1991 results and projects a harvest of 900 t and exports approaching $5 million. CamCar has placed a special emphasis on entering the Spanish market. Officials have contracted technical assistance from France-Aquaculture[119] and report yields of about 1.7 t per ha per crop in a 90-day cycle. The company has its own hatchery which in 1990 was the most productive Caribbean-coast hatchery (appendix H1).[120] (See: "XI. Postlarval Supply: Hatcheries.") It has also built its own feed mill.[121]

Caribeña: This company has signed a management contract with TMT, but no details are available on operations.

Cartagenera de Acuacultura (CARTACUA): The company is Colombia's leading shrimp culture firm and operates the largest farm. CARTACUA has carried out a major pond construction program and increased pond area to 400 hectares. The operation includes a processing plant and hatchery.[122] (See: "XI. Postlarval Supply: Hatcheries.") TMT has provided technical assistance [123] from the initial phases of site selection. The company was attacked by guerrillas in 1989. Even so, CARTACUA harvested 1,400 t of shrimp in 1990, nearly 25

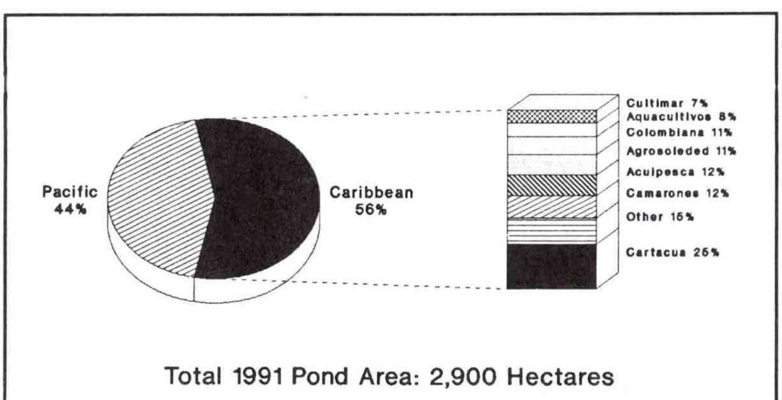

***Figure 6**.--Colombia. Cartacua has dominated Caribbean-coast farms, but several farms now operate substantial pond areas.*

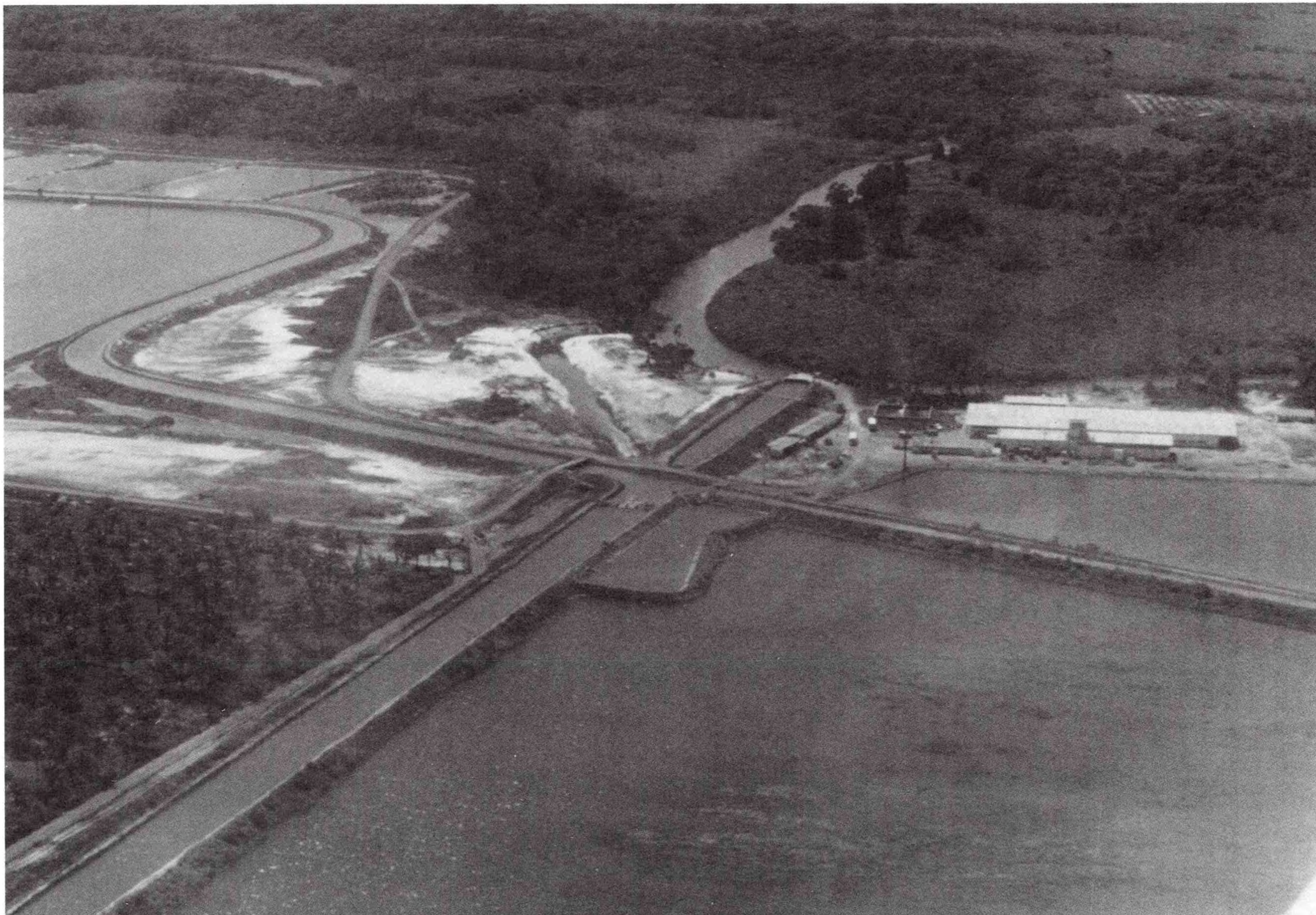

Photo 6.--*Colombia. The Catagenera de Acuacultura farm is a modern farm built along Colombia's Caribbbean coast. The farm has nursery (1 ha) and growout ponds (7-9 ha).* © *Henry Clifford III*

percent of Colombia's overall shrimp harvests. Export revenue in 1990 totaled about $7 million. Company officials are optimistic about 1991 and project a 1,900 t harvest permitting $10 million in export sales. This will be double the harvest and exports reported by any other farm.

Colombiana de Acuacultura: The company is located at the Bahía de Barbacoas. It is financed by the Grupo Azucarero Manuelita which also operates its own packing plant. Facilities include a hatchery constructed in 1986 with the capacity to produce about 15 million pl per month. The farm was designed and built by the U.S. Granada Corporation under a technology licensing agreement. Granada reports that the farm is located at a particularly promising site allowing the hatchery to be situated near the growout ponds.[124] TMT has also provided technical assistance. Colombiana initiated a major renovation and expansion program in 1988 and increased pond area substantially in 1989 and 1990. The farm operated about 170 ha of ponds in 1991. The company has the area to build another 500 ha of ponds in the future.[125] The area of ponds actually stocked improved notably in 1990. The 1990 harvests totaled 340 t and exports exceeded $2 million. Full utilization of the new ponds should permit a substantially expanded 1991 harvest. Colombiana is projecting a 640 t harvest and exports approaching $3.8 million in 1991.

Cultimar: The company has conducted a major pond construction program. As recently as 1989 they operated only 30 ha of ponds. Cultimar is operating 120 ha of ponds in 1991. The company harvested less than 100 t in 1990 because many of the new ponds were not fully operational. Company officials are projecting substantially improved results and 1991 harvests may approach 550 t which would generate over $2.5 million in export sales.

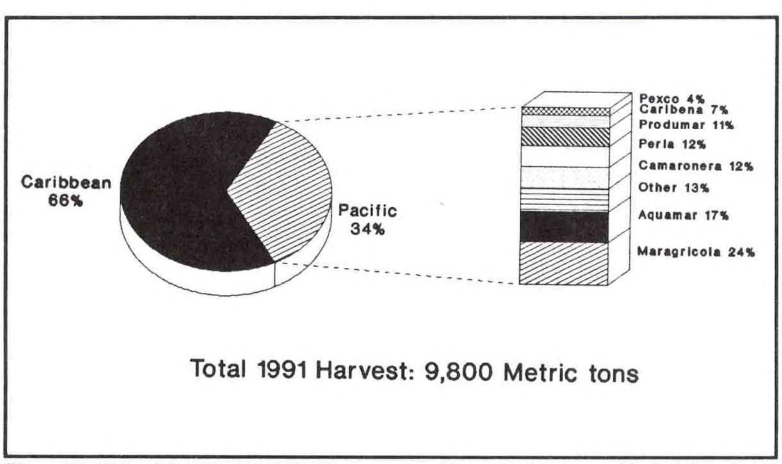

Figure 7.--Colombia. Pacific-coast farms currently report about one-third of the overall harvest. The leading farm is Maragricola.

Vikingos: The Vikingos Group is one of the pioneering companies in the Colombian fishing industry. It is currently made up of six separate companies, of which Vikingos de Colombia and Frigopesca are the most important.[126] The company continues to be one of the country's more important fleet operators and packers and is developing a 400-ha farm.[127]

Other projects: There are about eight additional shrimp farms along the Atlantic coast, all of which have less than 100 ha of ponds (appendices G2-4).

2. Pacific coast

Pacific coast growers in 1990 operated about 15 farms with a total pond area of 1,030 ha (1,750 ha constructed), all near Tumaco (appendix F).[128] There are three leading Pacific-coast farms, each with about 200 ha of ponds. Two other farms operate about 100 ha of ponds. The largest Pacific-coast farms include:

Aquamar: The company operated over 200 ha of ponds in 1991, a substantial increase over 1989 and 1990. The 1990 harvest totaled 325 t and export earnings nearly $1.7 million. Plans call for harvesting 575 t in 1991 which could generate up to $3.5 million in export earnings.

Camaronera Balboa: The authors have received some conflicting reports concerning the company (appendix G2-3). Company officials report operating 111 ha of ponds in 1991 and plan to expand to 230 ha in 1992. The 1990 harvest was about 200 tons. TMT is now managing the farm which is reporting improved results. Officials believe that the 1991 harvest could reach 400 t which would mean about $2 million in export revenue.[129]

Maragricola: The company is operating about 240 ha of ponds in 1991. It is owned by the IDELPACIFICO group. A substantial construction program was conducted in 1990, but so far the company has not increased the area of ponds utilized. The 1990 harvest totaled about 645 t and generated $2.8 million in export revenue. Company officials hope to harvest more than 800 t in 1991 and export up to $3.4 million. The company began experimenting with polyculture runs, mixing shrimp with red tilapia hybrids in 1990.[130] Officials report that tilapia can be added to existing ponds without impairing shrimp yields. Maragricola is reportedly achieving annual yields of 2.5-3.0 t of shrimp and

10.0-15.0 t of tilapia per hectare.[131] A processing plant is now functioning and has the capability to process 3,300 t of shrimp and 3,800 t of tilapia.[132] Maragricola also has an ice plant (20 t per day) and four cold storage chambers which can hold 230 t of product.[133] The company has also begun construction of a feed plant which will produce for both their own operation and for sale to neighboring farms.

Perla del Pacifico: The company launched a major construction program in 1989 and hopes to have 100 ha of ponds operating in 1991. While only small quantities of shrimp were harvested in 1990, company officials believe they may be able to harvest as much as 400 t in 1991. Such projections appear optimistic, but the company will almost certainly report a substantial 1991 increase.

PEXCO: This company has signed a management contract with TMT, but no details are available on operations.

Produmar: The company is operating about 115 ha of ponds. It reported its first harvest of about 85 t in 1990. As a result of its expanded pond area, Produmar could harvest as much as 360 t of shrimp in 1991.

Other projects: About 10 other farms reportedly exist in the Tumaco area, but only 6 were active in 1990. All of these projects had less than 100 ha of operating ponds each (appendices G3-4).

B. Freshwater farms

Very little information is available on companies or individuals which are working with freshwater shrimp. For the most part they appear to be small enterprises or individuals. One report indicates that **Acuacultora de Mariscos** (AQUAMARIS) at its Sabaletas farm in the Cauca Valley near Buenaventera (map 1B) was working with the Universidad del Valle on both growout and hatchery technology.[134]

C. ACUANAL

Growers created a trade organization to promote the aquaculture industry in 1985, the Asociación Nacional de Acuicultores de Colombia (ACUANAL). As of 1990 its membership included 23 shrimp farms and 8 trout farms. Despite its recent creation and relatively limited resources, ACUANAL has become one of the more active private industry groups in Latin America promoting the interests of the aquaculture industry. ACUANAL provides information to members and pursues various initiatives with Government agencies. ACUANAL also represents the aquaculture industry to various Government agencies considering proposals affecting fisheries development, import policy, regulatory coordination, marketing efforts, and other issues. ACUANAL is also promoting various research efforts. In addition, ACUANAL has attempted to coordinate activities with similar industry groups in Ecuador, Panama, and other countries, and possibly forming a regional aquaculture group--ALAQUA.[135]

VIII. METHODS

Early growers were uncertain about the optimal methods for Colombian growing conditions. Most simply adopted the extensive methods practiced in neighboring Ecuador which were achieving considerable success during the early 1980s.[136] Extensive farms were relatively inexpensive to construct and were easy for inexperienced Colombian growers to manage. Such farms utilized basic technology, required minimal staff training and only simple management procedures. Colombian growers have subsequently considered other alternatives. One researcher assessed the potential for cage culture.[137] Most important Colombian groups as the industry developed, however, have adopted semi-intensive methods. Colombian growers gradually concluded that the more sophisticated, semi-intensive methods, while requiring higher initial investments and operating costs, were in the long run more profitable. As a result, while a few smaller growers still use extensive or semi-extensive methods, the more important growers have generally shifted to the higher-yielding semi-intensive techniques developed by Caribbean-coast growers and their foreign consultants.

Several alternative monoculture methods have been tried in Colombia:

Extensive: Some of the earliest farms, built in the 1970s employed Ecuadorean-style extensive methods. These growers achieved little success. Growers found that, unlike Ecuador, operations without supplemental stocking were not feasible. Only small quantities of *P. vannamei* pl were naturally present in the water. Collecting wild pl, especially *P. vannamei* pl, proved much more difficult than initially anticipated. As a result of this and other problems, growers generally rejected the Ecuadorean-style extensive farms because of low yields and instead turned to more sophisticated approaches.

Semi-extensive: Several small farmers and some larger farms during their start-up phase employed semi-extensive methods, or perhaps more accurately described as primitive semi-intensive systems. These growers use relatively low stocking densities, 1-5 pl/m2. Few use supplemental feeding, relying primarily on the nutrients naturally present in the water. Productions costs as a result are low, but yields are also correspondingly low, varying from 0.2-0.5 t per hectare.[138] Smaller growers found it difficult to convert their existing ponds to more intensive methods because of farm design and the need for more sophisticated pond management. Smaller, less well financed, operations often cannot afford to make needed pond engineering modifications or to hire the consultants and better trained technicians needed for more intense pond management systems.

Semi-intensive: Colombian growers have built some of the best-designed semi-intensive farms in Latin America. Most growers use nursery ponds to improve survival rates and more efficiently utilize growout ponds. Growers currently report survival rates ranging from about 40-85 percent.[139] (The lower range of survival rates are generally reported by new entrants with limited growout experience.) Colombian growers have steadily improved survival rates. As of 1991, growers were reporting average survival rates of 70 percent and more.[140] Some of the more established companies are now reporting survival rates approaching 85 percent. Acclimatization and nursery management procedures vary from farm to farm.[141] The juveniles are generally transferred to the growout ponds when they reach 0.5-1.0 grams.[142] Growers currently employ relatively high stocking densities in their growout ponds which are increasingly reflected in the improving yields. The specific stocking densities employed, however, are often a function of the availability of pl, especially for those farms without their own hatcheries. (See: "XI. Postlarval Supply: Hatcheries.") Many growers stock growout ponds at 10-15 pl/m^2, but increasing numbers are now stocking at higher densities, especially along the Caribbean coast. One U.S. consultant reports stocking densities of 12-20 pl/m^2.[143] Caribbean stocking densities of 18-20 pl/m^2 are becoming increasingly common and some growers are reporting densities of up to 25 pl/m^2.[144] Semi-intensive growers are reporting somewhat different production cycles on the two coasts.[145]

Caribbean production cycles are about 146 days (120 day growout period and a 26 day period to prepare the pond for the next crop). Growers are reporting annual rotations of about 2.5 crops. Stocking densities are increasing to as much as 22 pl per meter^2.

Pacific production cycles are somewhat shorter, about 120 days. Growers are reporting annual rotations of about 3 crops. Stocking densities are substantially below Caribbean densities. Growers are increasing densities, but few stock at more than 13 pl per meter^2.

The high stocking densities now being used require supplemental feeding. (See: "X. Feeds.") Growers now commonly report 2.5-3.2 harvests per year. High density operations require careful pond management. Most farms have hired consultants, often foreign groups, to help develop and maintain optimal growout operations. (See: "XVIII. Technical Capability: Training/technical assistance.") Most observers report yields of 2-4 t per ha annually.[146] An increasing number of farms are reporting individual crops of 2 t per ha, which could mean annual yields of 4-6 t and more.[147](See: "IX. Yields/Production Costs.)

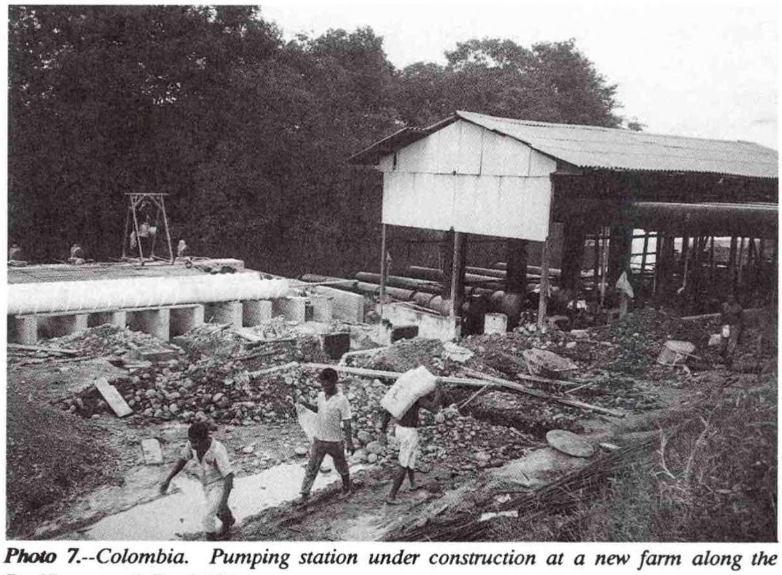

Photo 7.--Colombia. Pumping station under construction at a new farm along the Pacific coast. © David Larson

Intensive:There are no known intensive farms in Colombia, although one company, Aquacol, is reportedly considering a Japanese-style intensive farm.[148]Some observers believe intensive methods do not seem justified and would not take advantage of the many favorable economic and environmental factors in Colombia (warm climate, available and relatively inexpensive sites, low wage rates, etc.). Yields being achieved by growers are

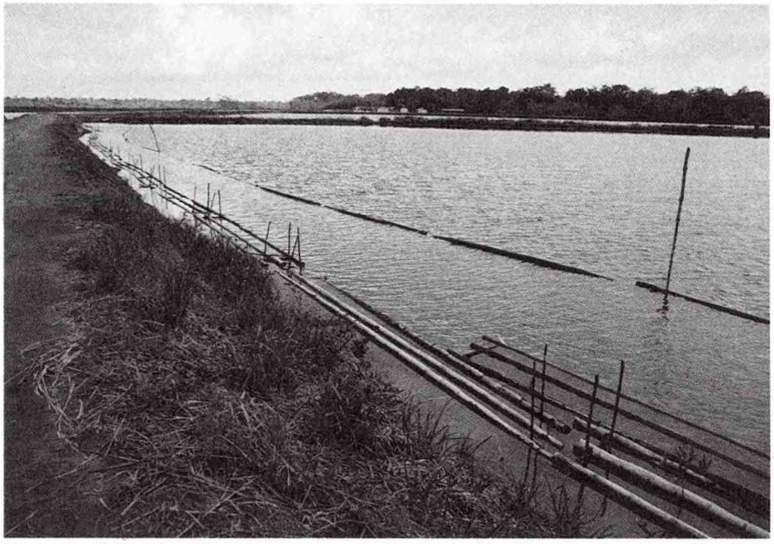

Photo 8.--Colombia. *Bamboo wave erosion break on Pacific-coast farm near Tumaco.*
© *Paul Maugle, PDM*

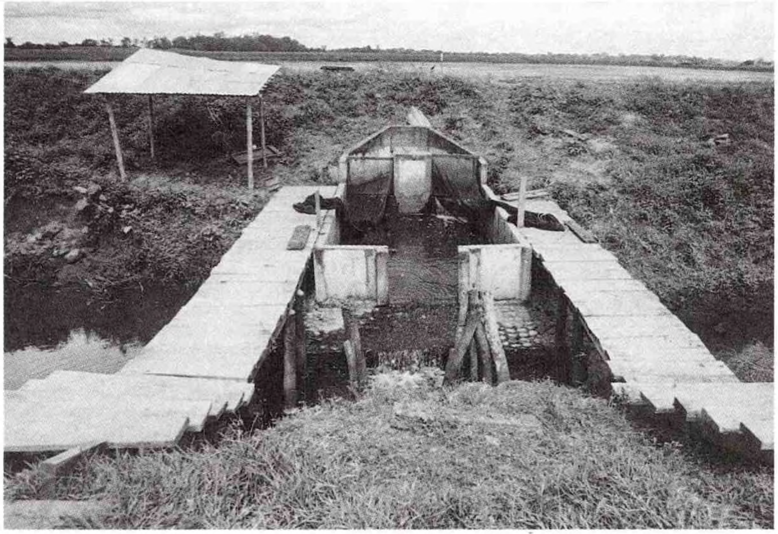

Photo 9.--Colombia. *A harvest gate set up for harvesting the following evening.*
© *Paul Maugle, PDM*

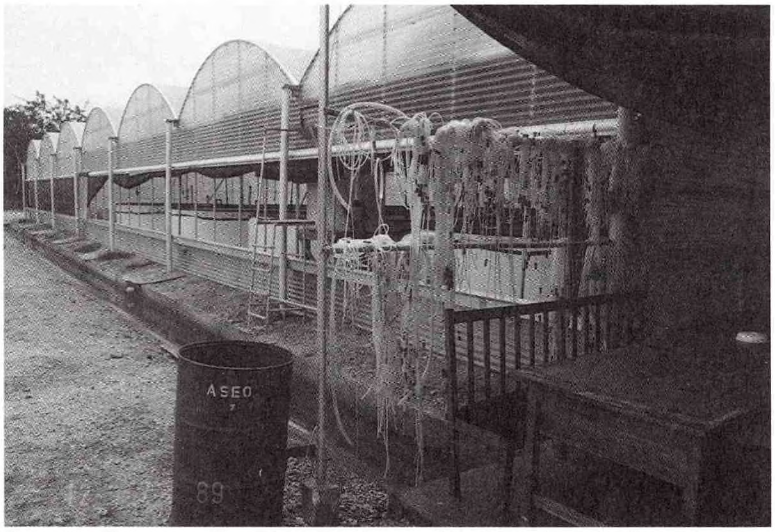

Photo 10.--Colombia. *View of the Isla Baru hatchery located outside Cartagena.*
© *Paul Maugle, PDM*

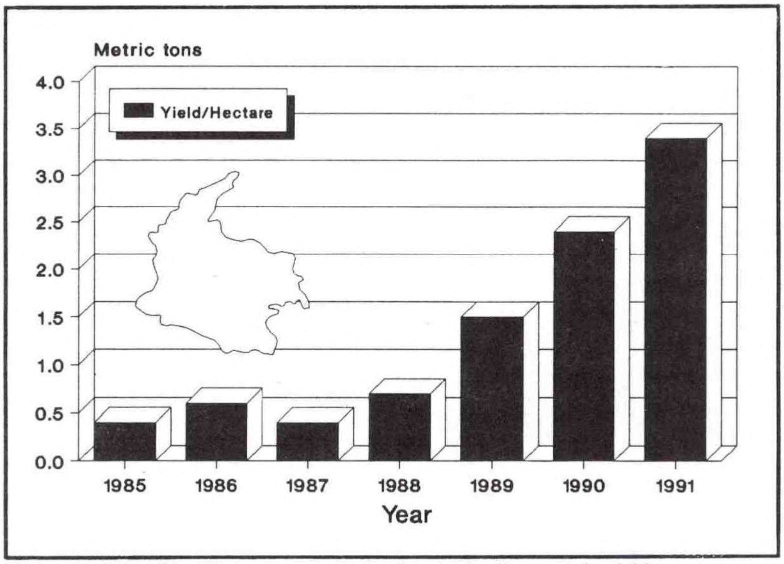

Figure 8.--Colombia. Growers are reporting impressive increases in yields.

sufficiently profitable that few are likely to shift to high-cost intensive operations. The authors do not have access to cost benefit analysis on intensive operations. Some observers believe that earnings increases would not justify the major capital investments which would be required. Even so, many of the more advanced semi-intensive growers are incorporating some intensive features into their growout operations. Some growers are considering aeration systems to increase stocking densities and yields.[149] Use of such features as aeration to support higher stocking densities, however, will be limited until the production of pl can be increased by the country's developing hatchery industry.[150] Some authors suggest that intensifying growout strategy is the wrong strategy for Colombian growers. One observer insists, for example, that a more effective strategy to accommodate declining real shrimp prices is to cut operating costs by reducing the intensity of pond management.[151] Another alternative is polyculture.

Polyculture: One Colombian company (Maragricola) is shifting to a polyculture system. Increasing monoculture yields beyond 2.5-3.0 t per ha requires costly additional investments (pond modifications, aeration, etc.) and, as a result, sharply higher operating costs (higher levels of supplemental feeding, increased energy consumption, etc.). Some observers believe that the cost of such modifications may not justify the higher yields achieved.[152] Polyculture offers growers a less costly alternative. Growers can use existing ponds without expensive redesign and engineering projects. Maragricola is currently culturing tilapia along with *P. vannamei*. Each species occupies its own ecological niche and thus does not compete with the other. The tilapia feed in the water column while the shrimp feed on the bottom. An Israeli company which has developed the technology reports that shrimp yields are unaffected by the tilapia, but that pond profitability is increased because the grower is able to harvest both shrimp and fish.[153] (See: "VII. Companies: Maragricola.") Other polyculture systems using freshwater shrimp and various other finfish are also being studied.[154]

IX. YIELDS/PRODUCTION COSTS

Colombian growers are currently reporting some of the highest yields being achieved anywhere in Latin America. A thorough assessment of Colombian yields, however, is not possible because precise yield data is not available to the authors. The available data is largely provided by industry sources and cannot be confirmed. In addition, available yield estimates vary somewhat from source to source and often are calculated on different basis.[155] While detailed yield data has not been published, the clear pattern suggested by available data is that Colombian growers are substantially increasing yields (figure 8). As recently as 1989, Colombian semi-intensive

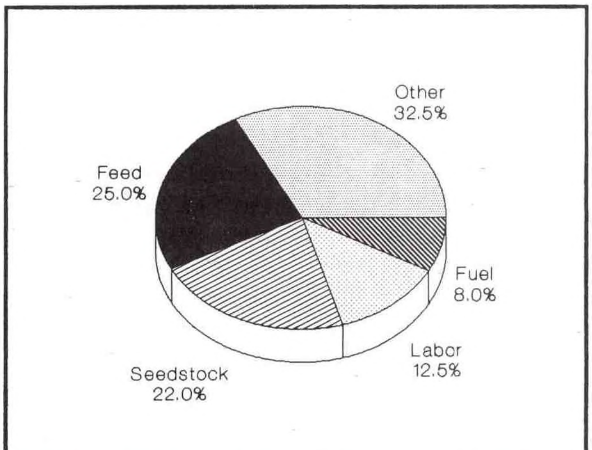

Figure 9.--Colombia. Seedstock and feed appear to be the largest factors for growers in Colombia.

growers were reporting yields varying from 1.4-2.8 t per year.[156] Such results were higher than Ecuadorean yields,[157] but within the norm reported by growers in many other Latin American countries. Colombian growers, especially Caribbean-coast growers, have since made spectacular progress in improving yields. The normal range is about 1.2-2.0 t per crop and up to 3 crops per year.[158] Several of the better farms report yields averaging over 2.3 t/ha per crop in large ponds.[159] The most recent data from Colombia indicate that some individual growers are achieving even better results. One observer reports, for example, that growers are achieving yields of 2.8 t per ha per crop.[160] ACUANAL confirms these impressive yields. At least some observers, however, are skeptical with the higher yields currently being reported by Colombian growers. These observers point out that many such estimates are based entirely on industry sources. Such yield statistics are in most cases based on data maintained informally by individual growers who have been know to inflate yield statistics for a variety of reasons.[161] While precise data on yields verified by independent sources is not available, it is clear that Colombian growers are reporting some very impressive yields.

Yields vary considerably by coast. While definitive industry-wide yield data is not available, growers along both coasts appear to be achieving some very impressive yields. One source reported that **Caribbean** growers were averaging 1.2-2.0 t/ha per crop.[162] Such high yields with up to three harvests per year would mean annual yields of 3.6-6.0 t per hectare.[163] **Pacific** growers report substantially lower yields. A local source reports that Pacific growers, despite their problems, still report yields in line with many other Latin American countries (0.5-1.5 t/ha).[164]

Available data suggests that the production cost structure in Colombia is similar to shrimp growers elsewhere in Latin America in that the major costs are for feed, seedstock, fuel, and labor (appendix D3 and figure 9). Colombian growers appear, however, to have unusually high seedstock costs, probably because of the extremely limited supply of available wild postlarvae. One observer reported in 1990 that rising seedstock costs were previously a major factor in increasing costs at Colombian farms, but have now stabilized. More recently growers have been reporting substantially increased feed and fuel prices.[165] Precise cost data has proven difficult to obtain. Individual companies treat such information as internal data and do not normally release it. Such data is critical, however, to any thorough assessment of the industry's prospects. Steadily improving yields cannot be properly evaluated unless the cost of achieving those higher yields is known.

Some limited data is currently available on actual production costs. One expert notes that Colombian farms have reported costs varying from $2-7 per kilogram.[166] An analyst with experience with both Caribbean and Pacific farms affirms that Caribbean coast growers report impressive production costs, substantially below Pacific-coast production costs.[167] Another observer in 1989 estimated semi-intensive costs at about $4.40 per kg (tails) and suggested that Colombian growers were mid-way between low-cost Ecuadorean growers and relatively high-cost Panamanian growers.[168] Most observers tend to report substantially cost differentials between Atlantic and Pacific growers. One expert, for example, estimates that production costs of $3.00-$3.50 per kg were reported by most Atlantic coast farms, but substantially more, about $6 per kg were commonly reported along the Pacific coast.[169] The higher Pacific-coast costs are reportedly due to lower yields, higher fuel and transportation costs, limited infrastructure, and greater difficulty recruiting personnel. ACUANAL has prepared a detailed economic study assessing the profitability of the industry. While it does not include financial statements from individual growers, it does present representative cost and income data for farm projects.[170]

X. FEED

The feed industry in Colombia is dominated by two companies, Purina and Raza. Most of the shrimp feed used in Colombia is domestically produced by these two companies. **Purina Colombiana** is one of the leading Latin American producers. Purina has two Colombian mills producing shrimp feed.[171] One mill is located at Cartagena and supplies Caribbean growers. The other is located at Buga, north of Cali, to supply Pacific-coast growers. The company's Colombian subsidiary did much of the initial work in developing pelleted shrimp feed. Purina feed production in Colombia has benefitted from the research work conducted by Ralston Purina in the United States and at its various Latin American subsidiaries.[172]

Purina feed formulas are essentially the same in each country, although some differences result from variations in the characteristics of local ingredients. Feed produced by each subsidiary has to be within the nutritional standards set by the parent company to ensure uniformity and product quality. The company currently offers a range of feeds in Colombia varying from 25-50 percent protein content.[173] **Alimentos Concentrados Raza** is the other major feed company. Raza is affiliated with the CARTACUA farm. Its mill is located near Bogota. The company has produced animal feed since the 1960s, and introduced a shrimp feed in 1986. Raza currently sells shrimp feeds that range from 30-40 percent protein and produces about 500 t of feed monthly.[174] The company's biggest customer is its CARTACUA affiliate which accounts for about half of annual production. Company officials say that they plan to produce a wider range of feed in the future, better formulated for Colombian conditions. Raza is currently focusing its research efforts on new binders and determining the appropriate nutrient levels for vitamins, minerals, and amino acids.[175]
Several smaller companies also produce shrimp feed. **Solla S.A.** is active, but no details are currently available on its operations. **Finca S.A.** has recently begun producing a balanced shrimp feed.[176]

Some feed is also imported, but the quantity is limited because the Government restricts feed imports. Importing is probably not a viable long-term option, given the quantities of feed the country's growing industry will require. The cost and complexity of importing and transporting large quantities of feed to isolated farm sites probably preclude this option for many farms.[177] Feed companies are more likely to import fish meal, premixes, and other supplements needed to produce shrimp rations locally.

The Colombian market is becoming increasingly competitive. Purina has been the dominant feed company in Colombia, controlling as much as 80 percent of the market. Purina is reportedly especially dominant along the Pacific coast. The company is experiencing greater competition as other companies expand operations and new companies, including some growers, introduce feeds.

The Colombian feed industry is expanding. Feed companies are responding to the increased demand as growers enlarge pond area and intensify pond management. One feed mill currently operates along the Caribbean coast and two additional mills are nearing completion.[178] **Concentrado de Baru** hopes to be operational by September 1991 and the **CAMCAR** mill will reportedly be operational by early 1992.[179] Other mills are planned along the Pacific coast. **IDELPACIFICO** is reportedly building a feed mill.[180] Two of the new producers claim that they will introduce a "high-quality" feed, but no details are currently available to the authors. Growers are hopeful that the new feed will help them improve yields, but others are skeptical until the feeds are proven in commercial runs.

Detailed information on feeds are not available. ACUANAL reports that conversion rates (feed to shrimp) average about 2.5 along the Pacific and 2.2 along the Caribbean.[181] Feed prices also vary somewhat by coast. Prices along the Pacific average about $0.54 per kg and along the Caribbean about $0.51 per kilogram.[182]

Several growers insist that one of the principal problems facing the industry is obtaining high-quality feeds.[183] Some sources report that growers are highly critical, claiming that the feed currently available to them does not produce the yields they believe are theoretically possible.[184] Not all growers are so critical. Another source suggests less vehement feelings on the part of growers, but says that some believe that quality could be improved.[185] Colombian growers describe various problems. Some say that the rations currently available are inadequate for high density operations. Others complain that the protein content of some feeds is too low. One observer noted in 1989 that available feed in Colombia had inadequate binding characteristics (resulting in low water stability) and contained elevated calcium levels (which can inhibit molting). He also noted that vegetable and animals fats were used instead of fishmeal.[186] Most growers complain of high feed prices and believe that constant price increases result from the lack of competition.[187]

Other sources are skeptical of such criticisms. ACUANAL officials maintain that the feed currently available in Colombia is of acceptable quality.[188] Feed companies contend that high quality feeds meeting grower needs are currently available in Colombia, but many growers are unwilling to pay the higher price for these feeds.[189] Purina reports that Colombian growers currently tend to order the mid-range of the product line.[190] Feed company spokesmen contend that while disappointing results may reflect a whole range of pond management options, growers often blame their problems primarily on feed quality. One Raza official identified pl quality, poor pond management techniques for dealing with the dry season, and disease as more likely causes of low farm yields.[191] Purina insists that they carefully monitor ingredient characteristics as part of a rigorous quality control program. They report that their feeds, for example, do not have excessive calcium levels.[192] Grower concerns over feed may in part reflect increasing competition in the industry. As feed is such an important cost in semi-intensive farms (appendix D3 and figure 9), increased expenditures for higher quality feed can add significantly to operating costs. Thus feed is usually the factor to which pond managers give the greatest attention. Purina currently makes a high-quality feed,[193] but it is more costly than the feeds that growers have been using. Some growers criticizing feed quality are not using the higher quality feeds now available in Colombia.

Feed quality is a problem in all important shrimp culture countries and not just Colombia. Considerable research has been conducted in several countries and knowledge of shrimp nutrition is increasing. As a result, the quality of feeds and yields achieved is increasing around the world. Researchers are only beginning, however, to understand the fundamental nutritional needs of shrimp. Many basic questions have not yet been adequately researched. Company spokesmen for major feed companies recognize that much basic research needs to be conducted. No one really knows, for example, what the amino acid needs are for "generic" shrimp, let alone the requirements of individual species. It will be some time before many important questions are fully researched. Very limited work has been done by Colombian researchers on growout nutrition.

The relatively small size of the shrimp culture industry in Colombia and other Latin American countries has not justified a major research effort. Thus, feed companies have not been able to develop feeds specifically formulated for local growing conditions and species. Limited budgets have also restricted work by the major research institutes. Feed companies in Colombia and other countries have primarily produced for poultry and livestock growers. The small, albeit growing, number of shrimp growers have constituted only a small market which did not justify a major research effort. This is changing now that growers are rapidly expanding pond area and intensifying stocking densities. As a result, feed sales are increasing. The limited research effort is not just the situation in Colombia. Latin American research groups, both Government and private, have conducted very small research programs on shrimp nutrition, as well as other subjects associated with shrimp culture.[194] (See: "XVIII. Technical Capability: Research.")

The feed situation in Colombia is more critical than in other Latin American countries because Colombian growers are using higher stocking densities. This means that the supplemental feeding must provide a larger portion of the shrimp's total nutritional needs than in countries where low-density, extensive culture is more widespread. As growers increase their stocking densities they have become more and more demanding on major characteristics such as protein content, water stability, and balanced nutritional requirements. Colombian growers view the feed quality as a significant and increasingly serious problem. Growers have improved their operations significantly in recent years which has permitted excellent yields from increasingly higher stocking densities. Many growers, however, are convinced that they can not increase stocking densities further without improved feeds.[195] Early operations were not overly concerned with high-quality feed. Using expensive, high-quality feed in ponds stocked at low density was not cost effective as it did not measurably increase yields. The higher stocking densities now being used, however, require the use of better quality feed.

Colombian feed mills will be able to find most ingredients locally. Some essential ingredients, however, will need to be imported. Components such as fish oil, fishmeal (especially high-quality fishmeal), pre-mixes, etc. are not produced domestically. Colombia's restrictive import policy complicates the process of obtaining such components and escalates prices to growers, adversely affecting the industry's competitive position. Colombia's participation in the Andean Pact, however, will facilitate fishmeal and oil imports from Peru, one of the major world producers. Other imported ingredients may be more of a problem. One consultant preparing an industry assessment recommended that these key ingredients should be given preferential import status.[196] Current changes in the import regulations as part of the Governments "Apertura" policy may ease this problem.

Some growers would like to shift production to more valuable larger shrimp (14 grams or larger). Shrimp growers throughout Latin America have generally focused production on medium sizes (30-40 count shrimp). Efforts to harvest larger individuals have usually resulted in unacceptably low yields. Colombian growers have reported similar difficulties in such efforts. Some attribute their difficulties to inadequate feeds, but this has not yet been determined.

XI. POSTLARVAL SUPPLY

Obtaining adequate postlarval seedstock is one of the most serious problems facing shrimp growers throughout Latin America. With few exceptions the industry has only developed significantly in countries (Ecuador, Guatemala, Honduras, Mexico, Panama, and Peru) with access to wild concentrations of *P. vannamei* pl which could be easily collected to stock ponds. Countries without access to wild pl have encountered difficulties developing a shrimp culture industry.[197] This is the major reason that no Atlantic/Caribbean-coast country has yet produced an important shrimp culture industry and has been a major impediment to the industry's development in Colombia.

Colombian growers initially encountered difficulties obtaining adequate postlarvae. Initial expectations that pl could be easily collected in Colombia proved erroneous. Pacific coast growers had trouble finding *P. vannamei* pl and Caribbean coast growers reported disappointing results with the indigenous species available locally. The pl problem proved insurmountable to several early growers. Growers were forced to import pl at considerable cost and most concluded at an early stage that hatcheries would be a necessary element of the country's shrimp culture industry. The pl supply problem became increasingly severe as growers steadily expanded their pond area (appendix D2 and figure 3) and thus their pl requirements. Demand has increased sharply in recent years and probably totaled about 1.4 billion pl in 1990 (appendix I4). About 2.0 billion pl may be needed in 1991, although available estimates vary somewhat.[198] The hatchery industry is reporting increasing success in meeting the escalating demand. Some observers believe that even without an important wild collection effort, adequate domestic pl production will be available from the increasingly successful hatcheries. Estimated hatchery production of 0.8 billion pl in 1990 (appendix H1-2) required substantial imports to fully meet demand, supplemented with small amounts of wild-collected pl (appendix I5). Some observers are reporting improved hatchery production and a more adequate supply of pl in 1991.[199] Given grower expansion plans, hatcheries will have to increase production sharply if seedstock demand is to be fully met during the 1990s. Colombian hatchery production is heavily dependent on imported nauplii. Only a few hatcheries have made important progress with closed-cycle maturation production.

A. Wild Collection

Colombian growers face a much more difficult seedstock problem than in neighboring Ecuador. Growers who have attempted to collect wild pl have reported generally poor results. It is apparently not worthwhile collecting either the broodstock or the pl to stock ponds. Collection efforts have found it particularly difficult to locate the *P. vannamei* that growers want.[200] Caribbean-coast growers have no access at all to wild stocks of *P. vannamei*. Pacific coast growers report local stocks of *P. vannamei*, but have only marginal success in locating pl concentrations and collecting large numbers as in Ecuador. Tumaco growers have reportedly been able to collect only small quantities of either wild broodstock or postlarvae. The authors know of no data assessing wild collection, but it probably accounted for less than 50 million pl during 1990. This would be only a minimal proportion of total pl supply (appendix I5). Despite the problems encountered with locating wild pl, some observers believe that more attention should be devoted to assessing potential wild supplies. One observer emphasizes the need for expanding wild pl collection to reduce the current near total dependence on imports and hatcheries.[201]

Many have concluded that pl is not as naturally abundant off Colombia as off Ecuador, Panama, and some other Pacific-coast countries. Not only does there seem to be smaller quantities of *P. vannamei* available, but the populations also appear to be much more disperse than off Ecuador. Colombia does not appear to offer the same conditions as in Ecuador where artisanal fishermen in 1-2 hours can easily collect a million *P. vannamei* postlarvae.[202] As a result, efforts to apply Ecuadorean pl collection techniques in Colombia have proven unsuccessful. Most growers concluded that they could not rely on wild-collected seedstock.

Observers offer various reasons for the scarcity of postlarvae. One observer suggests that the relatively narrow Colombian shelf does not support a large shrimp resource.[203] Another observer notes that Ecuadorean pl collectors concentrate on the interior areas of the mangrove estuaries where *P. vannamei* pl are most concentrated, but such an approach has not proven effective in Colombia. The heavy precipitation during the rainy season makes it difficult for pl to move into the estuaries. The large Colombian estuaries do not lend themselves to the collection techniques employed in Ecuador.[204] While growers have been able to collect some pl, the concentration of *P. vannamei* is usually quite low.

Any significant production of wild pl could prove highly beneficial to Colombian growers. Not only would wild pl help to increase yields, but it would help reduce the industry's current dependence on hatcheries and imported nauplii. This could help reduce the very substantial seedstock costs now reported by growers (appendix D3 and figure 9). An important collection effort, however appears unlikely at this time. No commercial group is planning such an effort. The authors know of no important effort by artisanal fishermen to launch an Ecuadorean-style collection effort. Little information is available to plan a collection venture.

Future wild-collection efforts should not be dismissed entirely. Locations along the Pacific coast may eventually be found where concentrated populations of *P. vannamei* or *P. stylirostris* pl can be collected. The Colombian wild pl situation has not been carefully studied and no information is currently available on seasonal fluctuations in the availability and species mix. Little is known about where the pl can be collected and the extent and distribution of either the *P. vannamei* or *P. stylirostris* resource. The inaccessibility of substantial areas along the Pacific coast further complicates such an assessment at this time.

Growers using wild pl have been unable to regularly obtain high concentrations of the preferred species. Some simply stocked whatever was available. As a result of disappointing results, many began pre-treating wild pl with freshwater for 3-5 minutes before stocking the survivors in nursery ponds at only about half of the normal density. The practice is designed to kill less-preferred species, especially *P. occidentalis*, which appear to have less tolerance to freshwater than *P. vannamei*.[205]

B. Seedstock imports

Pl imports account for 20-40 percent of the pl supply, depending on the availability of local hatchery postlarvae.[206] Imports probably totaled about 0.6 billion pl in 1990, nearly 40 percent of total supply (appendix I5). Growers initially imported pl themselves, but in recent years have turned increasingly to local hatcheries, most of which produce pl from imported nauplii. The primary sources for both pl and nauplii are Panama and Ecuador.

Panama: Most of Colombia's imported pl has been obtained from Agromarina de Panama and other Panamanian suppliers.[207] Panama has provided as much as 80 percent of total Colombian imports.[208] Agromarina has decided to limit its shipments solely to nauplii. The company does not want to put itself in the position of competing with the hatcheries to which it sells nauplii.[209] Agromarina has been the major supplier, but a massive new Panamanian operation, the Pacific Larvae Center (PLC), opened during 1991 and has started shipping nauplii. The PLC operation could substantially increase available supplies. PLC plans to produce up to 210-240 million nauplii a month .[210]

Ecuador: Almost all of the remaining imports have come from Ecuadorean hatcheries and artisanal collectors. As a result of Ecuadorean law restricting exports, however, Colombian growers have had to smuggle both pl and nauplii. The relative mix of pl and nauplii is thus unavailable. Despite the clandestine nature of this trade, it plays a critical role in supplying Pacific coast growers with seedstock. One observer reports, for example, that a 1990 official investigation of the smuggling operation resulted in a serious pl shortage and sharp pl price increases.[211] Even though the illegal shipments have proven indispensable, the illegal nature of the trade causes problems in shipment which adversely affect the quality of the postlarvae. Recent changes in Ecuadorean law[212] have allowed Colombian growers to legally import hatchery pl from Ecuador.[213] The importation of the Ecuadorean pl and nauplii, however, has been complicated by new Colombian regulations banning imports in an effort to control the spread of cholera. (See: "XIV. Processing.")

Colombian law requires that imported nauplii and pl be certified disease free. The Panamanian Government provides such certificates. The Ecuadorean Government has obviously not done so because until 1991 such shipments were illegal and all such shipments were being smuggled across the

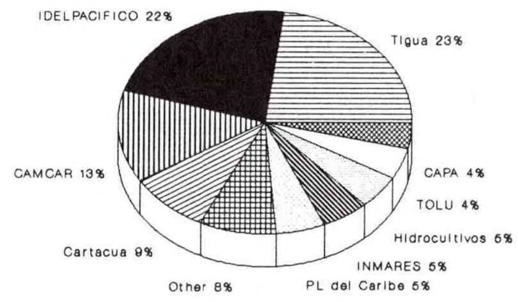

Figure 10.--Colombia. Several hatcheries reported sizeable pl production in 1990.

border. It is not know what Ecuadorean lab will now assess pl shipments. Given the continuing legal restraints on Ecuadorean shipments, however, the illegal pl trade may continue.

C. Domestic hatcheries

Colombia is rapidly developing one of the more important shrimp hatchery industries in Latin American. Most Colombian hatcheries are currently producing pl by the relatively simple process of using imported nauplii. Not only are the hatcheries now producing substantial quantities of pl, but increasing numbers of Colombians are acquiring basic hatchery technology, creating agrowing pool of experienced technicians for future expansion. Colombian groups have relied primarily on foreign technology, but some research has also been conducted in Colombia.[214] The primary focus has been marine shrimp, especially *P. vannamei*. Some research work, however, has also been carried out on freshwater shrimp.[215]

Most investors determined by 1985 that hatcheries would be necessary to assure a steady supply of pl and several hatchery projects were underway as early as 1986. The Colombian hatcheries vary significantly in size and technical sophistication.[216] Most of the Colombian hatcheries are fairly basic operations, purchasing nauplii in Ecuador and Panama to produce postlarvae. Only a few Colombian hatcheries are attempting closed-cycle maturation production. As elsewhere in Latin America, many of the new hatchery projects experienced difficulties. One observer reported that by 1989 only about 6 of the 12 hatchery projects underway at that time were operational.[217] More recent reports suggest that the industry is expanding very rapidly and achieving substantial success. About 20 hatcheries were reportedly operating in 1990 (figure 10), although some were still reporting significant difficulties (appendix H1). Observers vary somewhat on pl production at the hatcheries. Production probably totaled about 0.8 billion pl in 1990 (appendices H1, H2, and I5).[218] Colombian growers and hatchery managers are becoming increasingly concerned with quality. Growers and some hatchery operators confirm that the best pl is produced from nauplii obtained from wild spawners.[219] It is much more difficult, however, obtaining wild spawners in Colombia than in most other major Pacific-coast producers.

The assistance of foreign technical groups will be critical to the future development of a major Colombian hatchery industry. The utilization of imported nauplii has simplified the technology required. Some hatcheries have thus been able to produce pl with relatively simple facilities and basic technology. The major hatcheries attempting closed-cycle maturation have had to turn to foreign consulting groups. (See: "XVIII. Technical Capability: Training.") If Colombia is to expand its hatchery industry beyond the current system of relying on imported nauplii, a major effort will be required to obtain foreign technical assistance and train Colombian biologists and technicians. To a large extent, the process will be simplified by drawing on the experiences being gained at hatcheries in Ecuador and other Latin American countries. Even so, the industry faces a very significant technological challenge.

1. Individual hatcheries

Most Colombian hatcheries are located along the Caribbean near Cartagena. Only a few operating hatcheries are located on the Pacific coast.

a. Caribbean coast hatcheries

The Caribbean hatcheries include three large operations complete with sophisticated maturation facilities and 15 smaller operations which operate on imported nauplii (appendix H1).[220] Some of these hatcheries are extremely primitive backyard operations. One large hatchery (PROLARVAS) has experienced considerable difficulties, but is currently operating. Two of the most important hatcheries are run by CAMCAR and Cartacua.

Both are experiencing considerable success with their maturation operation and producing their own broodstock.[221] Some of the hatcheries (CAMCAR, Cartacua, and others) are operated by farms and the production primarily dedicated to the company's own growout ponds. Only limited details are currently available on individual hatcheries:

Acuacultivos del Caribe (ACUARIBE): This is a new hatchery project formed from the breakup of Agromarina Cispata.

Agromarina Cispata: This hatchery was initially part of a combined growout-hatchery project. The investors involved have reportedly decided to dissolve their partnership and operate the farm and hatchery separately. The new name is ACUARIBE.

Camarones del Caribe (CAMCAR): The CAMCAR hatchery, located near Cartagena, is the most successful Caribbean-coast hatchery. France-Aquaculture has provided technical assistance. The hatchery has eight 12 m^3 maturation tanks, and six 125 m^3 intensive broodstock ponds. Beginning in January 1990 they have been producing 35 million nauplii and 6-10 million pl (PL10) per month.[222] Total 1990 production exceeded 100 million postlarvae. Production was primarily *P. vannamei* (95 percent), but small amounts of *P. stylirostris* were also produced (appendix H1). Pl production is primarily used for the company's own growout ponds, but some excess production is being sold to neighboring growers. Plans called for operating the hatchery on captive broodstock beginning in 1991. One report suggests success with the first generation of broodstock.[223]

Camarones Triple K: The company planned to produce 70 million pl in 1992 with facilities totaling 80 kiloliters. The hatchery is located at Boquilla near Cartagena. Unlike several other hatcheries, they are not affiliated with a grower group.[224]

Cartagena de Aquacultura (CARTACUA): Pl production in 1990 totaled 70 million pl, mostly *P. vannamei* (85 percent) and *P. stylirostris* (15 percent) (appendix H1). Considerable success has been achieved in expanding output during 1991 and the company is reporting monthly runs of 15-20 million pl per month, consisting of both *P. vannamei* and *P. stylirostris*.[225] The company has the largest theoretical capacity of all the Caribbean hatcheries. TMT has provided technical assistance. Few details are available, but the pl output is primarily used for the company's own growout ponds. Some sources identify this hatchery as "Tigua" to differentiate it from the company's growout farm.

Corporacion Autonoma Regional de los Valles del Sinu y del San Jose (CVS): CVS runs the only state-operated hatchery. It was designed by INMARES to produce about 6 million pl monthly. INMARES also trained the staff and provided initial technical assistance.[226]

Demares: One observer reports that the Demares hatchery was closed in 1989. Another observer claims that the hatchery is currently being rebuilt and will be reopened in 1992, but this report has not yet been confirmed. One observer reports that the hatchery's production costs are very high.

Empresa Cultivos Acuaticos Punta Canoa (CAPA): The CAPA hatchery was designed by INMARES with a capacity to produce 5 million pl monthly. INMARES also provided initial technical assistance.[227] PROLARVAS rented the CAPA facility begining in December 1990.

Hidrocultivos de la Costa: This operation began as a primitive backyard operation. It produced about 56 million pl in 1990 and 78 million in 1991. The hatchery facilities have a capacity of 80 t of water. The hatchery in 1991 ran 11 cycles and achieved an average of about 7 million pl in each 20 day cycle. The hatchery was enlarged in 1991. During 1992, it operated with a capacity of 195 t of water and projected production of 14 million pl in 25 day cycles.[228]

INMARES: INMARES was founded as a consulting company in 1987 to assist Colombian companies building marine shrimp hatcheries. The company built its own hatchery in 1989, located only 5 minutes from Cartagena. The hatchery has eight tanks with a capacity of 11 t each. Production has avaraged 7.5 million pl monthly. The company has focused primarily on *P. vannamei* (80 percent), but also produces some *P. stylirostris* (20 percent) as well.[229] INMARES has also provided technical assistance for the CAPA, CUS, and Postlarvae del Caribe hatcheries.

Inveresiones Camaroneras: The company operates a closed-cycle hatchery at Cienaga, Magdalena. It is not associated with any Colombian farm and the company's only business is to supply postlarval seedstock to local and foreign clients. Nauplii are obtained through the company's own maturation efforts and imports. The company completed an expansion program in 1991 and now has a capacity of 336,000 liters. Company officials project production of 144 million pl annually. The company is also experimenting with the production of tilapia fingerlings to supply farmers interested in polyculture runs.[230] One observer reported in 1991 that they had not yet succeeded in producing postlarvae.

Postlarvas del Caribe: This is one of the larger Caribbean hatcheries. It produced over 40 million *P. vannamei* pl during 1990. The U.S. consulting firm RPI provided technical assistance during the late 1980s. The hatchery has also been assisted by INMARES which reportedly help maintain pl production averaging 2.0 million per month over a 2-year period.[231]

POSTLAMAR: This hatchery is a new larviculture facility with eight 10m^3 tanks for larval rearing. It is located near Tolú.

Productora de Larvas (PROLARVAS): PROLARVAS produces nauplii which it sells to smaller hatcheries without maturation facilities. Production reportedly totaled about 100 million nauplii in 1990 (appendix H1). Unconfirmed reports suggest considerable operating difficulties during 1990-91 as a result of a variety of problems, including poor sales and difficulties obtaining broodstock from Panama during that country's closed shrimp season. Technical difficulties with maturation efforts have also been reported. The hatchery is currently being run on an irregular basis as a backyard operation. PROLARVAS has rented the small CAPA hatchery which it operates as a larviculture station to produce pl with about half of PROLARVAS' nauplii production. Production in 1991 totaled 200 million nauplii, using about half of the maturation capacity. About 45 million pl were produced at CAPA. The company hopes to produce 400 million nauplii and 120 million pl in 1992.[232]

Rancho Chico: The Rancho Chico operation has four production tanks with a total capacity of 84 kiloliters and is adding an additional 16 kiloliters. Pl output totaled about 16 million pl in 1990 and 35 million in 1991. About 95 percent of production is *P. vannamei*, the rest is *P. stylirostris*. Sales in 1991 totaled $250,000.[233]

b. Pacific coast hatcheries

Only four hatcheries are known to exist along the Pacific coast (appendix H1).[234] The most important hatcheries in 1990 were IDELPACIFICO and Tigua. One hatchery, NAPASA, exclusively produces nauplii to supply the other hatcheries. Most of the hatcheries are located near Tumaco.[235] Available information on the hatcheries includes:

IDELPACIFICO: One report indicates that this hatchery is one of the most productive in Colombia. Almost all of pl produced is *P. vannamei*. Its production runs have been based almost entirely on nauplii obtained in Ecuador (90 percent), but recently they have also begun purchasing from NAPASA. The hatchery has a capacity of 250 million pl per year, based on 10 production cycles.[236] The hatchery reported production of 175 million pl in 1990 and sales of $13 million.[237] Industry officials projected increased production in 1991,[238] but a virus problem early in the year impaired several runs. As a result, total 1991 production was also about 175 million postlarvae. Actual sales totaled 110 million pl valued at $0.8 million.[239] The company operating the hatchery also has growout farms (Maragricola and two others) and a processing plant.

Nauplius del Pacífico (NAPASA): Unconfirmed reports suggest that a closed-cycle maturation hatchery opened in 1991 and is producing up to 5 million nauplii per day.[240] The hatchery is also located in Tumaco.

Post-larvas del Pacifico: This new hatchery reportedly opened in 1991 and is currently offering pl for sale. No details are available on the facilities.

2. Situation

The hatchery situation in Colombian has been complicated by the recent appearance of small, primitive hatcheries along both coasts. These "backyard" hatcheries are extremely rudimentary operations built to produce pl from imported nauplii. In many instances they have utilized old houses and other existing structures. Operators simply run a pipe out into the ocean to obtain seawater. Pl production is conducted in simple plastic lined tanks. Most have one air conditioned room which serves for algae production. Production at these hatcheries generally varies from 0.5-1.0 million pl per month. They are not generally operated year round, but only when pl demand is strong and imported nauplii are readily available.[241] Many farms have built such hatcheries, but others have been built by independent entrepreneurs. Some observers express concern over the operation of the growing number of these hatcheries. The operators using extremely basic technology and, for the most part, minimally trained technicians, are not capable of the more rigorous quality control operations conducted at the larger hatcheries. The potential for disease outbreaks, like the one which occurred in Taiwan, is thus intensified as these hatcheries proliferate. (See: "XIX. Diseases.")

Colombian growers do not report the kinds of problems with hatchery produced pl that Ecuadorean growers reported in the 1980s.[242] Most observers agree that the best results can be achieved with wild postlarvae. Ecuadorean growers accustomed to wild pl, constantly criticized the quality of hatchery postlarvae. There are several reasons why Colombian growers have not expressed similar complaints.

Experience: Few Colombian growers have extensive experience with wild pl and thus cannot make comparisons with the more available hatchery postlarvae.

Pond design: Most Colombian farms were designed as semi-intensive operations with nursery ponds and special procedures for carefully handling postlarvae. The current generation of Colombian growers knew from the outset that they would have to rely on hatchery pl and thus farm operations were designed to efficiently use postlarvae.

Quality: Some observers also believe that the major hatcheries are gradually improving the quality of their output and implementing increasingly effective quality control programs.[243] As a result, the hatcheries are narrowing the differences between the performance of wild and hatchery postlarvae. One expert speculates that perhaps Colombian growers are producing better quality postlarvae. This appears unlikely, however, given the extensive use and ready supply of wild spawners in Ecuador.

Selection: One observer suggests that the primitive conditions at many of the small-scale hatcheries subject pl to many of the stresses of natural conditions, thus culling out the weaker animals.[244]

Growing conditions: Colombian growers are obtaining such high yields that they are satisfied with the quality of hatchery postlarvae. Those high yields appear to be a reflection of the very favorable growing conditions and excellent pond management, and are not an indicator of higher quality postlarvae.[245] (See: "IX. Yields/Production Costs.")

Industry sources vary as to the most effective direction for the Colombian hatchery industry. A few companies have built large, sophisticated maturation hatcheries in an effort to free growers from dependence on climatic cycles and foreign suppliers. Other companies decided that the best approach for Colombia was to build relatively basic hatcheries designed to produce pl from imported nauplii, rather than focus on the more costly, technically demanding closed-cycle maturation hatcheries.[246] Many would argue that at this stage of the country's development and given the critical shortage of Colombian specialists, this low-tech approach is probably the most suitable strategy. This is especially true because nauplii are readily available in Panama and Ecuador and hatcheries in both countries are planning to expand production.

3. Problems

Colombia's new hatcheries are a critical element in the country's expanding shrimp culture industry. The limited supply of wild pl means that Colombia must either produce pl seedstock in hatcheries or import nauplii/postlarvae. While several hatcheries are reporting difficulties, especially with maturation, many are now successfully producing substantial quantities of pl from imported nauplii. The hatchery industry, however, faces some serious problems:

Shortage of trained technicians: Few Colombian experts have the advanced academic training necessary to run a sophisticated maturation hatchery for *Penaeid* shrimp. Some hatchery managers hired newly graduated biologists with the expectation that they would be able to conduct shrimp maturation operations.[247] The results have often been disappointing. For the foreseeable future there is likely to be a great need for qualified technicians. Colombian universities do not, however, currently offer courses that would adequately equip Colombian graduates for such work. (See: "XVIII. Technical Capability: Training/Technical assistance.") This problem is especially serious given the dimensions of the expansion projected by Colombian growers and, as a result, the increasing requirement for postlarval seedstock.

Limited maturation hatcheries: Only a few Colombian hatcheries have operational closed-cycle maturation systems (appendix H1). Most hatcheries have chosen less demanding work producing pl from berried females or nauplii. This approach is currently successful in supplying substantial quantities of pl to growers. Not pursuing maturation, however, means that pl production will be subject to the same natural climatic cycles which affects both the availability of wild pl and berried females. Hatcheries attempting closed-cycle maturation have reported financial problems because their production costs are relatively high. The availability of more inexpensive nauplii from Panama may make it difficult for Colombian hatcheries to continue costly closed-cycle maturation operations. The more sophisticated Colombian hatcheries are also finding it difficult to compete with the many new "backyard" hatcheries. A hatchery cannot operate for long periods selling pl below production costs, especially those hatcheries not associated with growout operations. The large maturation hatcheries have special problems because the costly facilities carry a heavy debt burden. Growers are unwilling to pay premium prices for closed-cycle hatchery pl when good yields can be obtained from the pl produced with imported nauplii.[248]

Dependence on imported nauplii: Colombian hatcheries are highly dependent on imported nauplii. This is primarily because most of the current hatcheries do not have closed-cycle maturation systems and must purchase nauplii to produce postlarvae. The few hatcheries which do have maturation systems do not produce a sufficient quantity of nauplii to sell to the other hatcheries on a regular basis. Local nauplii are not available as there are few enterprises supplying wild broodstock in Tumaco,[249] as is common in Ecuador. Hatcheries such as IDELPACIFICO are beginning to report progress in producing nauplii domestically, but most hatcheries currently have no alternative but to import nauplii from Panama and Ecuador. This has caused sharp swings in the availability of pl as the Colombian hatcheries have difficulty obtaining nauplii during the seasonal periods when berried females are normally scarce in Panama and Ecuador (especially November through February). During this period, some Colombian growers have had to postpone stocking. As a result the Colombian farms are very dependent on foreign hatcheries. Any problems which develop in Panama or Ecuador could have a devastating impact on Colombian growout operations.

Import restrictions: Colombia's restrictive import policy, especially the prior licensing requirement, has created problems for the hatcheries in obtaining a wide variety of items not produced in Colombia. The hatcheries need equipment, instruments, chemicals, medicines, *Artemia*, and other items, often on short notice. Even minor delays obtaining needed items can cause very significant problems.[250] The Government's new Apertura Economic Policy[251] is easing some of the import restrictions, especially the prior licensing requirement. Unconfirmed reports from Colombia suggest that the Government is also preparing a new aquaculture law which will include some duty free preferences.

D. Demand/supply situation

The current pl situation appears stable. Pl appear to have been available in adequate quantities during 1989 and 1990 to meet grower demand.

Demand: Colombian growers until recently required only small numbers of pl because of their limited pond area and low stocking densities (appendices I1-3). Growers in 1985, for example probably used less than 0.1 billion pl (appendix I4 and figure 11). The rapid expansion of the industry after 1986 has created a sharp escalation in the demand for postlarval seedstock. Demand has increased sharply in recent years and was probably about 0.6 billion pl in 1989 (figure 11).[252] Many growers reported difficulty obtaining adequate pl in 1989, but the situation improved in 1990 and even more in 1991 as hatchery production increased.[253] Existing data suggests that demand may have reached 1.4 billion pl in 1990, but various observers provide a range of estimates.[254] Very substantial increases are anticipated during the 1990s. Some observers believe that demand could reach to 3.0 billion pl by 1992 (appendix I4 and figure 11).

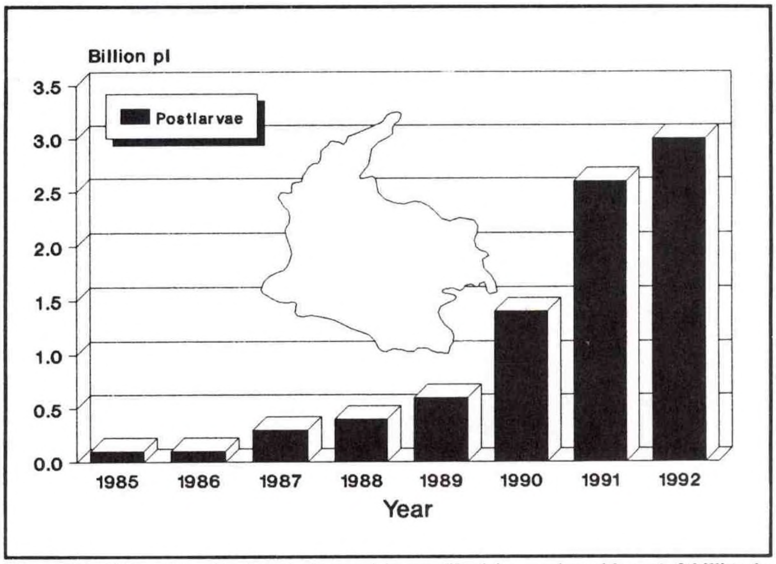

Figure 11.--Colombia. Seedstock demand is steadily rising and could reach 3 billion by 1992.

Supply: Precise data on current pl production is not available; however, it is possible to make some rough approximations. No data is available on wild collected pl, but it is believed to be relatively small amounts, substantially less than 0.1 billion pl in 1990.[255] Imports probably totaled about 0.6-0.7 billion postlarvae. Caribbean hatcheries produced nearly 0.5 billion pl in 1990. Pacific production was probably 0.3-0.4 billion (appendices H1-2 and I5). (Much of the pl production of both Caribbean and Pacific hatcheries is produced from imported nauplii.) Overall Colombian pl production thus totaled about 0.8 billion pl in 1990 (figure 10). The overall 1990 supply may have totaled about 1.6 billion pl (appendices H2 and I5 and figure 12), about the same as 1990 demand. Little information

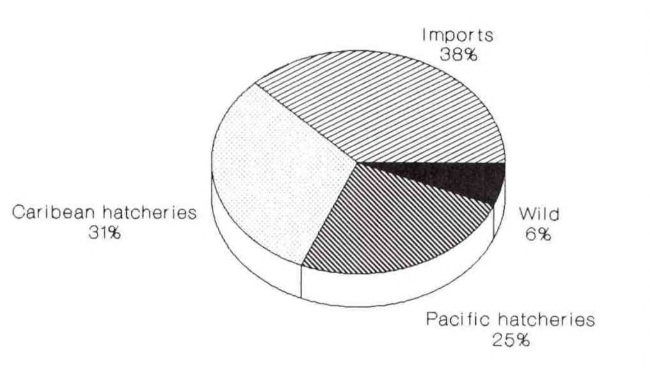

Figure 12.--Colombia. Seedstock is primarily provided by domestic hatcheries, although imports are still important. Increasingly foreign suppliers, however, are shifting to nauplii rather than postlarvae.

is available on actual 1991 hatchery production, but unconfirmed reports suggest increasing runs. One observer reports that "abundant" pl was available from the hatcheries during 1991.

Prices: Price estimates vary. One observer estimated pl prices at about $7 per 1,000 postlarvae.[256] Another report suggest slightly higher prices of about $8.50 per 1,000 postlarvae. ACUANAL reports prices vary from coast to coast and in 1991 were averaging $7.50 per 1,000 pl along the Pacific and $9.00 per 1,000 pl along the Caribbean coast.[257]

The future pl situation is unclear. Clearly Colombian hatcheries will have to substantially increase production to meet the very large expansion anticipated in grower pl demand. The ability of the hatcheries to expand production rapidly enough to meet the expected pl demand is unknown. Hatchery operators have clearly made substantial progress in 1989 and 1990. The experienced gained during that period appears to be helping operators to achieve 1991 production increases. Their ability to fully meet anticipated demand in the 1990s is uncertain. Such a rapid expansion in a technically sophisticated new industry suggests that continued difficulties at many hatcheries are likely, especially sophisticated closed-cycle maturation operations. The situation is complicated by the lack of Colombian training programs for hatchery technicians and the need for continued reliance on foreign technical consultants. The sophisticated maturation hatcheries need constant supervision by trained, experienced personnel. The hatcheries, however, are located at isolated locations where living conditions are often rudimentary. This makes it difficult to attract and retain highly trained staff, especially foreign technicians. Relying on foreign hatcheries for nauplii supplies further complicates the Colombian supply picture. Several industry observers remain confident that the expanding hatchery production supplemented with some imports will meet expected demand for the foreseeable future.

The economic state of the hatcheries is also unclear. Expanding production appears to be limiting pl prices. Competition from the increasing number of low-cost "backyard" hatcheries is further intensifying competition and may in the future have a major impact on prices. This could adversely affect the sophisticated maturation hatcheries with heavy debt burdens. One hatchery operator, for example, maintains that the market is saturated and that hatchery operations are no longer a promising growth industry in Colombia. Other operators are more optimistic, especially those who have built the more basic hatcheries relying on imported nauplii.

XII. HARVESTS

A. Marine species

Colombian marine shrimp growers are reporting substantial success, despite the relatively recent development of the industry. Some observers are now pointing to Colombia as the fastest growing aquaculture industry in Latin America.[258] Colombian harvests have doubled every year since 1985 (figure 13). The 1990 cultured shrimp harvest of about 6,000 t is a nearly 100 percent increase over the 1989 harvest of 3,000 tons (appendix C1 and figure 13).[259] ACUANAL predicts that growers will operate over 2,900 ha of ponds in 1991 and harvest nearly 10,000 t of shrimp (appendices C1 and D1). It is likely that the pond harvest will surpass the trawler catch in 1991 for the first time (appendix C1 and figure 2). The industry's rapid growth, however, appears to be slowing. Pond construction is not accelerating (appendices D2 and F). Cultured harvests should continue expanding during the 1990s, but at a slower rate. A variety of unquantifiable variables make it impossible to project future harvests with any precision. Some rough projections, however, are possible. Growers should be able to reach harvest levels of about

30,000 t by 2000. More optimistic projections suggest even larger harvests are possible. Such projections, while speculative at this point, should not be dismissed.

1970s: A number of isolated attempts were made during the 1970s to culture shrimp, mostly along the Pacific coast.[260] Growers hoped to take advantage of the natural supply of *P. vannamei* pl, but most experienced problems collecting the wild postlarvae. Few Colombian investors had any academic background or experience with aquaculture. The first farm was built by Camarones Guapi during 1974.[261] The farm was located along the Pacific coast in Cauca Province. It utilized modified Ecuadorean extensive methods, but closed after operating only briefly.

Early 1980s: Several growers attempted to culture shrimp, but almost all encountered serious technical difficulties. Most thought that they could simply employ the extensive system developed in Ecuador. Colombian biologists who had worked in Ecuador naturally attempted to transfer the methods they had employed. This approach, however, proved unsuitable for Colombian conditions. Growers generally failed to carefully assess local conditions. Many underestimated the technical difficulties and failed to contract needed technical assistance. Major mistakes were made in site selection and pond design. Obtaining wild pl proved to be a serious problem. Caribbean growers achieved disappointing results with indigenous Caribbean species. Pacific growers were hampered by the limited infrastructure which complicated both pond construction and operations. Despite the difficulties, a few groups persisted, impressed with developments in other countries, especially neighboring Ecuador. They built a small number of ponds and conducted trial runs. As late as 1982, however, there were no reported Colombian shrimp harvests (appendix C1). Most groups reported that investments exceeded expectations. Production costs proved higher than planned and yields were far below expectations. The combination proved disastrous and many farm projects failed.[262]

1983: Construction of the first large, commercial farm began in 1983.[263] Interest focused primarily on marine shrimp, but some investors also assessed the potential for freshwater shrimp.[264]

1984: Growers reported their first significant commercial runs in 1984, harvesting about 40 tons. More importantly, the Colombian Government designated the shrimp culture industry as a major developmental priority, offering Government financial and technical assistance to the new industry. The Fondo de Promoción de Exportaciones/Colombian Government Trade Bureau (PROEXPO) initiated a major program to assist growers. (See "XVI. Government Role.") Optimistic newspaper and magazine articles alerted investors to the opportunity afforded by the new industry.[265]

1985: Government promotion efforts and the success of the industry in neighboring Ecuador continued to attract investor attention. A few important investment groups began to make commitments to the industry, significantly increasing the resources available to growers.[266] The total pond area was little more than 400 ha and harvests were only about 100 tons. Many growers reported continuing difficulties obtaining seedstock as efforts to collect pl in the wild yielded insufficient quantities. Increasing numbers of growers decided that the industry's development required hatcheries.

1986: Optimistic reports continued to appear in newspapers and magazines.[267] Various economic groups reported substantial new investments. Government sources reported that by 1986 about 80 different groups had submitted proposals for shrimp culture projects. About 14 groups were actively conducting growout operations and 6 groups began constructing hatcheries.[268] New growers expanded the pond area to 900 ha and harvests exceeded 400

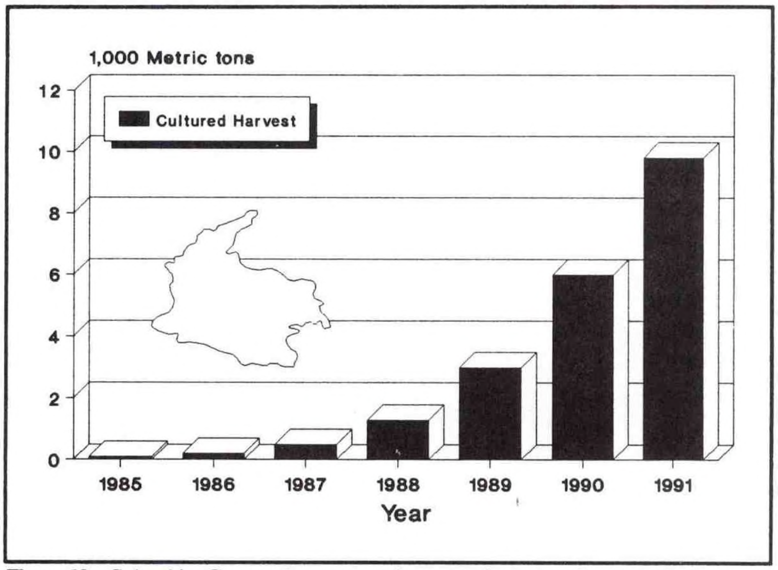

Figure 13.--Colombia. Growers have reported some major harvest increases during recent years.

tons (figure 13). Export earnings reached the $1 million level and growers began efforts to enter the European market. Many of the new growers, however, reported considerable difficulties. Even with PROEXPO assistance, the Government regulatory regime proved daunting. (See: "XVI. Government Role.") Commercial banks continued to express great reservation over loans to the unproven new industry. Some researchers questioned the impact of the shrimp culture industry on the environment. Growers reported increasing difficulty obtaining postlarval seedstock. Caribbean growers reported poor results from indigenous species and increasingly turned to the more proven *P. vannamei*, requiring them to import pl from foreign hatcheries--mostly in Panama. Ecuadorean law prohibited pl exports, although some was smuggled to supply Pacific (Tumaco) growers. The high cost of the pl[269] caused growers to stock at relatively low densities. Several growers expressed dissatisfaction with the poor quality and limited availability of feed. The combination of inexperience, some badly designed ponds, the use of indigenous Caribbean species, and low stocking densities produced disastrous results. Many growers reported yields of only about 0.2-0.3 t per ha, a fraction of what they had anticipated.

1987: The year proved to be the critical turning point for the industry's development. Several important new projects expanded pond area to 1,800 ha (appendix D1). The overall harvest totaled only about 500 tons (figure 13) and export earnings were about $2.4 million (appendix J1). Despite the increases, earnings were limited by declining real export prices, especially for the medium sizes harvested by growers. Growers also had to contend with changes in loan terms as commercial banks began tightening credit policy. Some growers continued, however, to report considerable operating difficulties. (See: "1986" above.) The combination of these factors caused serious financial problems at several farms. Some of the new shrimp culture projects were formed with limited capital resources. Several already existing companies had to close and others were reportedly near bankruptcy. Others had to make major adjustments and had to curtail or delay construction programs. Most groups found that construction costs exceeded initial projections and returns were far below expectations.[270] By the end of 1987, about 30 of the 80 groups conducting or considering shrimp culture projects were forced into bankruptcy or had to cancel or scale back construction plans. Many questioned the industry's viability in Colombia. Only about 12 companies had the economic resources to conduct serious growout efforts. Many investors sold their farms or sought additional participants to obtain additional operating capital. Several groups turned to foreign (mostly United States) consulting groups.[271] Colombian growers had contracted foreign consulting groups previously, but on a much more limited scale. During 1987 several important farms signed major technical assistance contracts with TMT and other consultants which were to play a critical role in their subsequent success. Investors along the Pacific (Tumaco) reported the greatest difficulties. PROEXPO attempted to assist the growers who managed to survive and offered to refinance several projects, extending repayment schedules. The Fondo Nacional de Garantias assisted several groups which had limited collateral to offer commercial banks. The Government approved several hatchery projects to help deal with the pl shortage. Not all growers reported problems. Two particularly well financed Caribbean coast projects (CAMCAR and Cartacua) began reporting impressive yields. Both contracted foreign technical consultants to improve growout methods and construct hatcheries. These two projects served as models for the rest of the industry.[272]

1988: The growers who survived the 1987 crisis built relatively few new ponds in 1988. As a result, pond area increased to only 2,100 ha (appendix D1). The utilization of existing ponds, however, improved dramatically. The increasing experience of the growers and important improvements in pond management resulting from foreign technical assistance began having a major impact on results. The hatcheries reported substantial production successes, significantly increasing the availability of seedstock. Growers reported improving yields and some were able to harvest up to three crops during the year. Several Caribbean coast growers reported yields exceeding more established farms in Ecuador and other Latin American countries. Growers were thus able to achieve substantially improved harvests. While still small, the 1,300 t harvested in 1988 (appendix C1 and figure 13) was a major increase over 1987 and confirmed what could be accomplished. Growers more than doubled export earnings to $7 million (appendix J1 and figure 14). Several farms reported substantial sales in the new European market.

1989: Pond construction resumed in 1989 as investors began to assess the improved 1988 results. Pond area exceeded over 3,000 ha by the end of the year (appendix D1). Growers continued to report improvements in hatchery operations and growout methods. Pl prices declined to about $8.50 per

1,000. Several farms reported major successes with improving yields, but many also reported difficulty obtaining adequate postlarval seedstock. The industry as a whole more than doubled harvests to nearly 3,000 tons (figure 13), mostly from Caribbean coast farms (appendix F). Exports totaled $16 million (appendix J1).

1990: Extensive pond construction projects continued and pond area reached 3,800 ha (appendix D1). Hatcheries reported sharply higher pl production, significantly improving the availability of postlarval seedstock.[273] Growers not only operated more ponds, but reported substantially improved results because of the greater availability of pl and increasingly effective growout methods. Colombian growers reported some of the highest yields in Latin America, in some cases two to three times higher than those commonly reported in Ecuador and other Latin American countries. Growers again doubled their harvests to about 6,000 t (appendix C1 and figure 13). Caribbean growers continued to dominate the industry, but Pacific growers also reported impressive increases (appendix F). Exports nearly doubled to over $30 million (appendix J1 and figure 14). Industry groups, however, expressed concern over new government economic policies. The Government initiated the new Apertura economic policy in February 1990, limiting several promotional programs affecting shrimp farmers. (See: "XVI. Government Role.") Some observers warn that despite the substantial harvest increases, many farms have very significant debt burdens.[274]

1991: Most important companies are reporting considerable success and should achieve record results. Some of the marginal producers are withdrawing. Fewer construction projects were planned for 1991, but better utilization of ponds, increasing experience, and improved methods should permit another major harvest increase. Industry sources report increasing successes at many hatcheries and an abundant supply of postlarvae. Most project excellent 1991 harvests. Overall yields will continue the highest in Latin America. Several farms have increased their initial harvest projections. ACUANAL is projecting a 1991 harvest approaching 10,000 t (appendix C1 and figure 13) and actual harvests may be even higher. Caribbean growers continue to dominate the industry, but ACUANAL believes that Pacific growers will double harvests (appendix F). Exports should exceed $50 million (appendix J1). The industry is reporting, however, rising debt levels and increasing difficulties obtaining credit.

1990s: The steady expansion of pond area and improving yields suggest that Colombian growers should be able to achieve very significant harvest increases during the 1990s. Precise projections can not be made, however, as future industry expansion will be determined to a large part by international shrimp prices. The real price of shrimp has fallen dramatically during the 1980s. If this trend continues, the profitability of cultured operations would be impaired and the industry's growth affected. Pond construction appears to be tapering off and, as a result, harvest increases will probably not occur as rapidly during the 1990s as occurred during the 1986-90 period. A conservative projection of current trends suggests that Colombian growers should be able to achieve a 30,000 t harvest by the year 2000.[275] Major problems with shrimp prices, pl supply, feed availability, or a serious disease outbreak, however, could dramatically change that outlook. While these potential problems could create major difficulties, some observers believe that a 30,000 t harvest by 2000 is too conservative. Given Colombia's potential, it is not impossible that growers could achieve substantially larger harvests by 2000.[276]

B. Freshwater species

Various groups have also experimented with freshwater shrimp, but few details are available to the authors. Growers have turned primarily to *M. rosenbergii*. Postlarvae are reportedly available from four different hatcheries.[277] (See: "III. Species.") PROEXPO claims that growers began producing freshwater shrimp in 1987, but provided no details.[278] FAO reported only small harvests (1-3 t) from 1985 to 1988, but a 50 t harvest in 1989.[279] One INDERENA report in 1988 indicated six different groups were conducting freshwater shrimp runs, but with only 3 ha of ponds. Another report suggested that one company attempting to culture freshwater shrimp experienced significant difficulties.[280] The most recent available report suggests that two freshwater shrimp projects were reportedly to have begun production in 1991.

XIII. HARVEST PROCEDURES

ACUANAL reports that most Colombian growers have implemented efficient harvest systems to increase efficiency and improve the quality of the harvested shrimp. Most of the important farms harvest shrimp by draining their ponds and collecting the shrimp in nets placed at the water outflow pipes. Caribbean growers are reportedly purchasing Sort-Rite harvest pumps. Harvests are normally conducted to take advantage of the cool nighttime temperatures. Growers usually begin harvesting around 10:00 pm and most complete the operation by about 4:00-5:00 am. Packing plants deliver ice to the farms in insulated plastic containers called "refrigadoras."[281] The harvested product is immediately packed in plastic containers and covered in flake-ice for transport to the processing plant.[282] Most Pacific coast growers deliver their harvest to the processing plants by launch. Transportation times along the Pacific coast vary from 1-3 hours as the farms are all quite close to Tumaco. Caribbean coast growers deliver their harvest by truck. Transportation times along the Caribbean tend to be somewhat longer because of poor roads and the fact that some farms are further away from the processing plants. Growers report a significant weight loss ("merma"), averaging about 7 percent from harvest to arrival at the processing plants.[283] The loss is due to dehydration and varies according to time lapse and conditions in which the shrimp are maintained.

Growers adjust harvests to achieve the maximum economic returns. Managers are theoretically able to alter growout schedules and time harvests to take advantage of current market trends. Currently Pacific growers harvest primarily 61-70, 51-60, and 41-50 count shrimp. Caribbean coast growers focus on the mid-range sizes, reporting mostly 51-60s, 41-50s, and smaller quantities of 61-70s and 36-40s.[284] ACUANAL reports a substantial difference between the size of the shrimp harvested by Pacific and Caribbean growers.[285] The reason for this difference is unknown.

XIV. PROCESSING

Colombia has only a small number of packing plants processing shrimp for export.[286] Few details are available on the packing plants, but in several instances investors participate in both packing plants and farms. Several new packing plants have opened in recent years, in many case eclipsing the established packers which focused primarily on the trawler catch. The new packers in many cases are not geared to handle trawler landings and are often not even located along the coast where trawlers can dock. They also are maintaining a more stable, and thus more efficient labor force, because they do not have to hire large numbers of poorly trained temporary employees to handle the usual sharp seasonal fluctuations in trawler landings.[287]

Caribbean: The Caribbean packers are primarily located in the Cartagena area. One of Colombia's most important shrimp companies is **Vikingos de Colombia** which has been servicing Caribbean-coast fishermen for years. Vikingos currently has the capacity to process over 1.1 t of shrimp tails and 1.2 t of whole shrimp per hour. Actual production totals about 7.3 t of whole shrimp and tails daily. Most of the tails are delivered by the trawler fishermen and the whole shrimp by the growers. The company was never able to land enough shrimp from its own trawler fleet to adequately supply its processing plant. For several years the company contracted foreign trawlers (Honduras, Japan, Panama, and the United States). Expanding cultured harvests, however, are allowing Vikingos company to operate closer to capacity. The company is now planning a second plant which will be designed specially to handle cultured harvests. Vikingos packs boxes of frozen shrimp tailored to the target market: IQF shrimp, deveined, and peeled shrimp, packed in polyethylene bags. There is also a small production of value-added shrimp products (shrimp cocktail, breaded, and diet breaded) which are reportedly being well received by U.S. clients. The company reports that its export shipments are directed at three markets: Japan (65 percent), the United States (25 percent), and Europe (10 percent).[288] Other Caribbean-coast plants include: **Oceanos** and **Coapesca**, but little information is available on these plants. New companies are entering the industry as the expanding shrimp farm industry increases harvests. The **Cartagena Shrimp Company** has built a packing plant at the Cartagena Free Trade Zone. The plant is a state-of-the-art facility processing primarily IQF product, but also has the capability to block freeze and handle whole as well as headless shrimp. The company reports that it is handling pond harvests for shipment to both the United States and Europe.[289] Processing costs average about $1.00 per kg.[290]

Pacific: Three packing plants at Tumaco process much of the farmed product.[291] The most established company is **Delfin Blanco** which has been packing fish and trawler-caught shrimp for years. The company does not own any farms, but

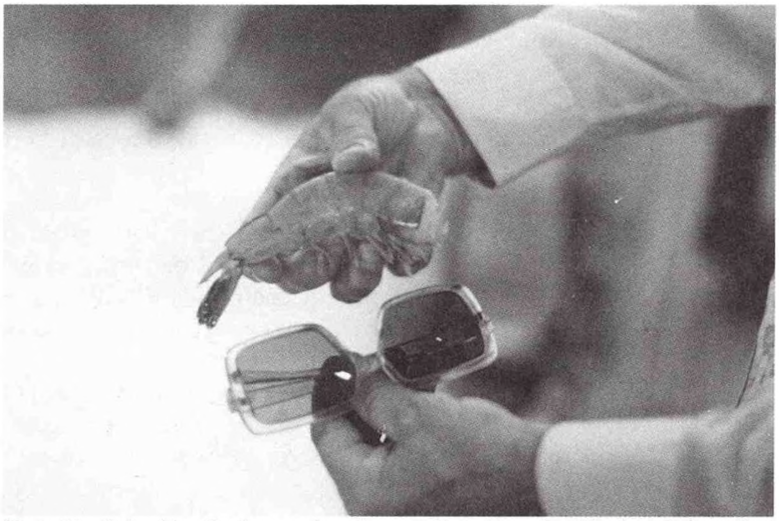

Photo 11.--Colombia. Packers produce frozen tails, but are also shipping whole product to the EC. Dennis Weidner

does operate some vessels. It reportedly exports primarily to the United States, but also ships smaller quantities to Japan. The two other packing plants are especially geared to process cultured shrimp. **IDELPACIFICO** opened a packing plant in September 1990.[292] The company reportedly was built by a group of three growers and exclusively processes their harvest. Processing costs average about $0.92 per kg, but Tumaco growers have to pay another charge of about $0.22 per kg for transport to the port at Buenaventura for export shipment.[293]

Despite the construction of new packing plants, some observers report that the packers are having difficulty keeping up with the rapid increase in pond harvests. One observer reports a growing bottleneck at the processing plants and indicates that growers occasionally have trouble processing their harvest, especially during peak harvest periods. This forces the growers to delay harvests, raising production costs.[294]

Colombian packers primarily produce frozen tails as the een the dominant target market. GrowersUnited States and Japan have traditionally b are, however, increasingly expanding production of whole shrimp for European markets. The product forms readily available from Colombian packers include: block-frozen tails, P&D and PUD tails, cooked whole and tails, IQF (nitrogen tunnel) whole and tails, semi-IQF whole, and small quantities of value-added products. Some observers suggest that growers and packers should give more consideration to producing various value-added products.[295] Few Colombian companies, however, have made an effort to do so. One observer reports that Colombian companies have not followed up on such opportunities, even citing efforts by a Spanish company interested in producing cooked shrimp in Colombia.[296] The industry's continuing credit problems and the more involved marketing challenge of exporting value-added product partially explain the reluctance of many Colombian companies to make substantial commitments.

Colombian growers claim that their shrimp is of especially high quality because of the care taken in harvesting and processing. ACUANAL trade publications assert that growers give special attention to ensuring product quality. The short time interval from harvest to packing plants and the heavy use of ice suggest that the Colombians are producing a quality product. Empirical studies, however, comparing the quality of product from various countries is not available. Scattered reports from U.S. importers suggest that Colombian shrimp is of high quality, but not noticeably superior to product from Ecuador and other important producing countries in the region. Some U.S. importers have noted a lack of uniformity in some Colombian packs.[297] This probably reflects the rapid expansion of the industry. Packers use both machine and hand grading. Packers have hired many new workers to handle the increasing pond harvests in 1990 and 1991. These new, inexperienced workers may explain some of the grading problems. Some importers have also noted a color difference in the Colombian Pacific-coast product, but it does not affect the quality of the product. (See: "V. Growing Conditions.")

The cholera outbreak, which began during early 1991 in Peru and has since spread to neighboring Latin American countries, could have an impact on Colombian and other Latin American-origin shrimp exports. Cholera can be spread through uncooked seafood. The U.S. Food and Drug Administration (FDA) has added a test for cholera to its inspection of shrimp and other crustaceans from Colombia as well as Ecuador and Peru. Some European countries have also instituted measures to ensure that tainted seafood does not enter their markets. Thus far FDA has not detected legal strains of the

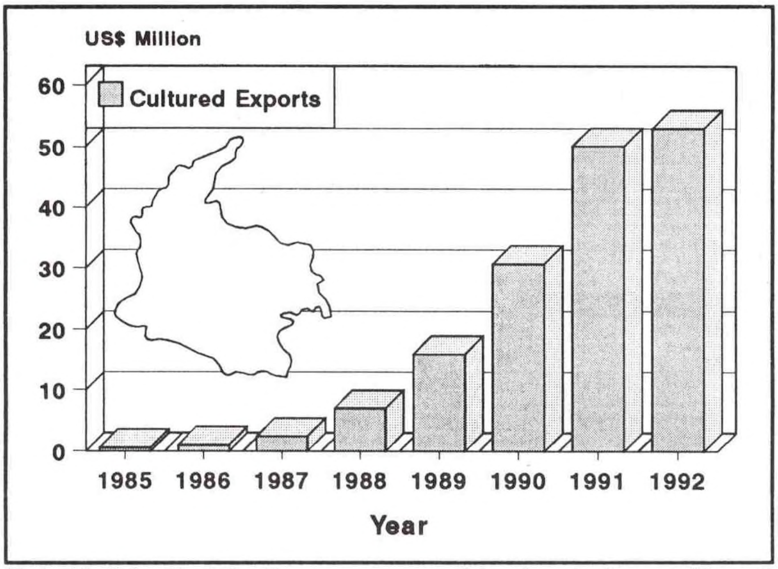

Figure 14.--Colombia. Colombian growers are reporting major gains in export shipments.

cholera virus in any Colombian or other Latin American product.[298] Some observers believe, however, that Latin American countries face a continuing problem with cholera during the 1990s. The perception of a lower quality or tainted product could lower demand for Latin American shrimp.[299] In addition, the FDA 100 percent inspection rule may complicate customs procedures and cause delays. Importers may consider alternative sources.[300] Industry officials seem anxious to dispel concerns about cholera, emphasizing the wholesomeness of their product.[301] Monthly U.S. import data thus far indicate no significant decline in purchases of Colombian product (appendix J6). This may be partially due to a sharp decline in white shrimp shipments from China in early 1991, creating strong demand for Latin American whites.

XV. MARKETS

A. Domestic market

Growers market small quantities of shrimp domestically. One report estimates that domestic sales account for only about 5 percent of the harvest. Most of the domestic sales are small sizes, broken pieces, and shrimp which does not meet international quality standards. Shrimp marketed domestically is generally sold for substantially less than the export shipments. ACUANAL estimates, for example, that in early 1991, domestic sales averaged about \$3.40 (Pacific) and \$4.40 (Caribbean) per kilogram. The higher Caribbean prices were reportedly due to the more developed market along the Caribbean coast.[302]

B. Export markets

Cultured shrimp is one of the new non-traditional industries which Colombia has developed with great success during the 1980s.[303] Shrimp growers have become the country's primary producers of shrimp for export (appendix C1 and figure 2). The rapidly expanding pond harvest has enabled growers to increase shipments from only \$2 million as recently as 1987 to over \$30 million in 1990 (appendix J1 and figure 14).[304] Growers in 1990 supplied nearly 40 percent of all exported fishery products. ACUANAL estimates that growers will ship over \$50 million of shrimp in 1991 (appendix J1 and figure 14). Most of Colombia's cultured shrimp exports are harvested by the 12 leading growers (appendix G1-4).

Colombia is only a minor factor in the international shrimp trade.[305] Colombian exports account for less than 1 percent of the total world trade. As a result, the country's exporters have not had sufficient product to establish a clear identity

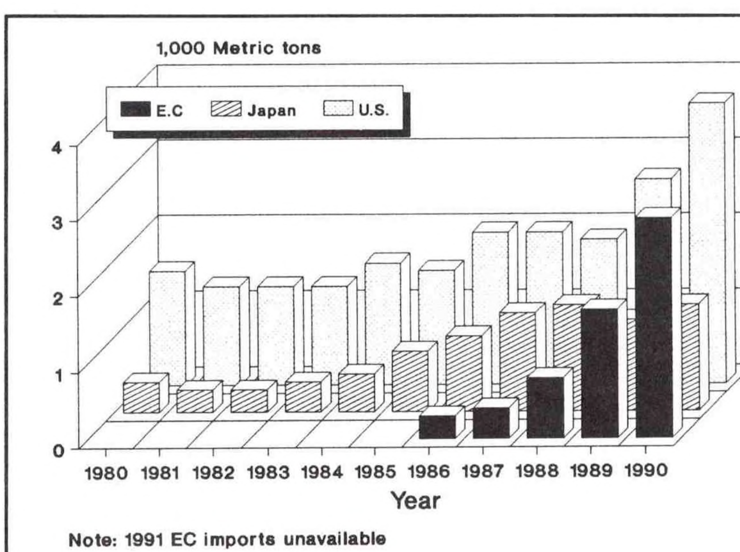

Figure 15.--Colombia. Exporters ship to each of the major world markets and are reporting major success in the European market. The shrimp shipped to Japan, however, is almost entirely trawler-caught shrimp.

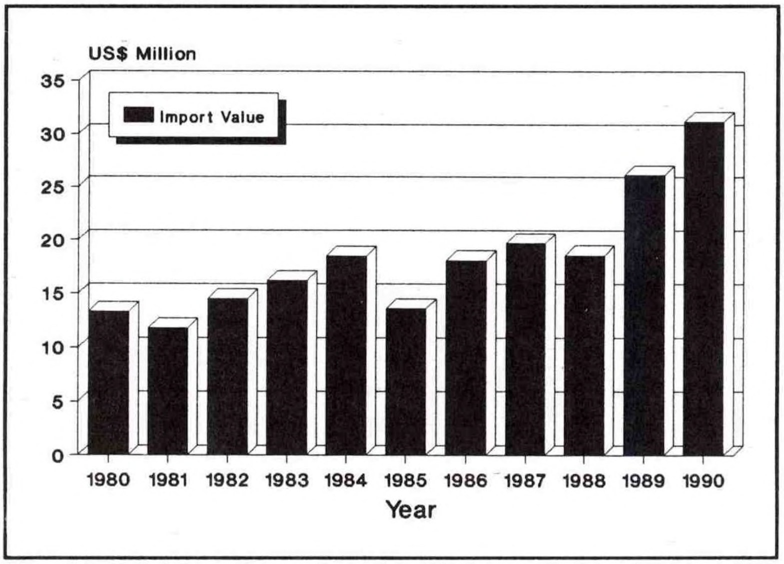

Figure 16.--United States. Imports from Colombia increased substantially since 1988, primarily because of the expanding pond harvest.

for Colombian product in important export markets. Some observers believe that Colombian growers need to give more attention to marketing. One observer, for example, points out that few companies have an executive position fully devoted to marketing and sales. He maintains that such a situation is highly unusual for companies which, in Colombian terms, are relatively large enterprises.[306]

Colombian growers primarily target the United States (tails), but shipments to Europe (whole) are increasing (figure 15).[307] Several companies reportedly now market most of their harvest in Europe. Shipments of cultured shrimp to Japan, however, are negligible and are unlikely to significantly increase during the 1990s.

U.S. market: The United States is Colombia's major market (appendix J3 and figure 15). U.S. imports from Colombia were relatively constant during most of the 1980s. Shipments ranged from 1,300 t (1981) to 2,000 t (1987). Despite weaknesses on the U.S. shrimp market, Colombian companies began to increase shipments significantly in 1989 as a result of the expanding farm harvests. U.S. imports totaled a record 3,700 t in 1990, an increase of nearly 40 percent over 1989 shipments (appendix J4). The value of those shipments have increased sharply since 1988 and exceeded $30 million in 1990 (figure 16). Growers anticipate setting another record in 1991. The rapidly expanding pond harvest is permitting growers to increase shipments to the United States as well as to develop new markets in the EC. The United States is the major market for Colombian shrimp, but beginning in 1988 the United States received less than half of total Colombian shipments (appendix J3). Colombian shipments to the United States are primarily shell-on tails, but a small amount of product is peeled (appendix J5). Existing size-count data is impossible to analyze as a large portion of the shipments to the United States were not classified. Shipments to the U.S. are made by both Pacific and Caribbean coast growers, but much of the product now coming to the United States is harvested at the Pacific-coast farms. Product forms vary, but one processor reports that most of its U.S. shipments are 5-lb boxes of frozen shell on tails.[308]

European market: Latin American growers are reporting considerable success in the European market. The primary participant is Ecuador because of the substantial quantity of product available, but other Latin American countries are also participating.[309] Colombian companies first began shipping shrimp to Europe in 1986 (appendix J3) and have reported substantial increases during

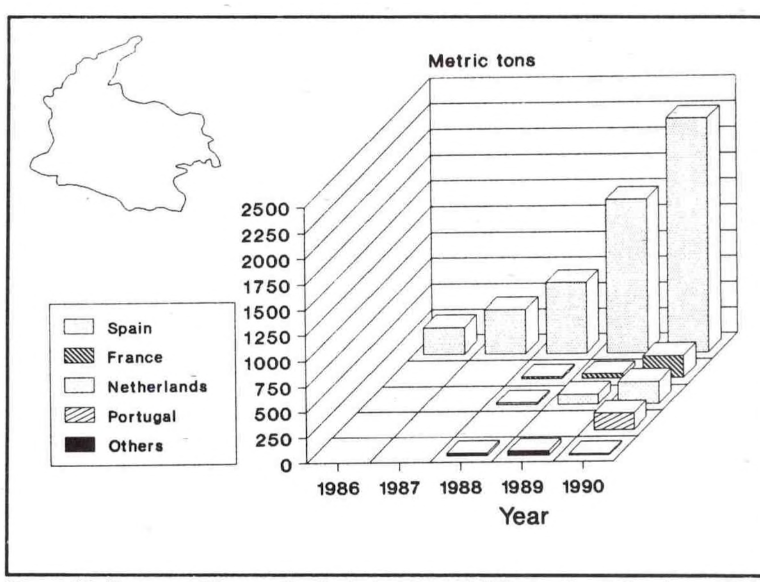

Figure 17.--European Community. Spain is substantially increasing shrimp imports from Colombia.

1988 and 1989. One Caribbean-coast processor reports shipments are mostly 2-kg boxes of whole shrimp, both trawler caught and cultured product.[310] Shipments in 1989 totaled 1,700 t, making the EC Colombia's second leading market (appendix J3 and figure 15). Colombia's principal EC market is Spain which accounted for about 90 percent of 1989 shipments (appendix J7 and figure 17). Colombian companies report that success in the Spanish market was not easily achieved. Growers had to adjust harvest methods. Packers had to change processing, packaging, and transport techniques. Producing whole animals in perfect condition proved especially difficult. Despite these problems, in just 2 years most important Caribbean companies had successfully made the transition, demonstrating how rapidly technology can spread within the industry. Prospects for Colombian shrimp are best in the southern European countries, Spain and to a lesser extent France, as consumers in those countries are most familiar with tropical shrimp species.[311] ACUANAL reports that 1991 shipments to Europe have expanded sharply because of a 25 percent increase in prices for whole shrimp.[312] Almost all of the European shipments are Caribbean-coast product. ACUANAL estimates that in 1990 as much as 60 percent of the Caribbean harvest was marketed in Europe.[313] PROEXPO believes that the penetration of the Spanish market was a major achievement and that there are good prospects for expanding sales to other European countries.[314] Some progress has reportedly been made in the French market, but many observers believe it will prove more difficult to penetrate than the Spanish market.[315] Unconfirmed reports suggest that some Colombian companies have experienced significant problems with regulations imposed by the French Government to ensure that Latin American product is cholera free. There appears to be significant longer-term potential for increasing sales to other countries. Important European countries such as Germany currently import only small quantities of shrimp, especially tropical shrimp. Opening these new markets, however, will require a major promotional effort. (See: "XIV. Processing.") The impact of the EC effort to create a common internal market by 1992 is unclear at this time, but some Colombian observers believe it will create important opportunities for exporters.[316]

Japanese market: Colombia is one of the few Latin American countries which markets a substantial part of its shrimp in Japan. Some companies ship most of their product to Japan. Commercial links were established when Vikingos contracted foreign fishermen to supplement its small trawler fleet.[317] Exports to Japan continued even after the Japanese withdrew their vessels. One exporter indicates that shipments are mostly 2-kg boxes of frozen shell-on tails.[318] During the early 1980s shipments totaled about 300-400 tons. Imports have been increasing and since 1987 have varied from 1,200-1,400 t (appendix J3). Almost all of this product, however, has been the pink shrimp taken by trawler fishermen and not the white shrimp harvested by the growers.[319] Colombian pinks and Mexican browns are used in Japan's popular sushi bars. Colombian pinks are also reportedly used by major hotel restaurants. Japanese consumers apparently find the trawler-caught shrimp taste better than cultured shrimp.[320] (Some reports suggest, however, that sushi bars are gradually replacing frozen Colombian pinks with live Asian black tigers.[321]) Japan is the leading world market for imported shrimp, but Colombian growers will find it very difficult to penetrate this key market. Japanese imports of Colombian shrimp, for example, were surpassed by EC purchases in 1989. Colombian growers have encountered intense competition from various Asian growers in the Japanese market. Colombian pond harvests are almost entirely white shrimp, but Japan currently has access to Chinese white shrimp at prices substantially below those Colombian exporters can command in the United States and Europe. As a result, Colombian companies have little incentive to enter the demanding Japanese market.

FEDESARROLLO conducted a study of new Colombian export industries in 1990 financed by the Ford Foundation. The study focused on shrimp culture, flowers, and graphic arts. FEDESARROLLO concluded that the success of the shrimp growers was due to the ability of growers to master the technical requirements, the favorable growing conditions, and the success in opening new European markets. FEDESARROLLO also found the support of PROEXPO and the growers' ability to learn from the experience of Ecuador and other countries were other important factors.[322]

XVI. GOVERNMENT ROLE

A. Institutional framework

The primary Colombian agency responsible for fisheries is the Ministerio de Agricultura (MDA). Fishery matters are administered by the Division de Recursos Naturales (DRN) which has assumed the responsibilities of INDERENA. The DRN administers fisheries along with its major responsibilities, agriculture and livestock. The Government decided in 1990 to centralize fishery and aquaculture programs within the DRN into one unit specifically responsible for fisheries, the Instituto Nacional de Pesca y Acuicultura (INPA).[323] The Government created a Comisión de Pesca (CDP) in 1980 to help coordinate policy and allow private groups to work with Government agencies. Some observers question the effectiveness of the CDP which has not held regular sessions.

Many other agencies have various roles in regulating the fishing industry. The Ministerio de Salud (MDS) is responsible for health standards. The MDS has delegated its responsibility for regulating import and export standards to the Instituto Colombiano Agropecuario (ICA). In addition the Instituto Colombiano de Normas Técnicas y Calidad (ICONTEC) establishes processing standards. The Dirección General Marítima y Portuaria (DIMAR) is responsible for maritime and port matters. The Instituto Colombiano de Comercio Exterior (INCOMEX) sets export marketing standards. Many other federal and local agencies have responsibilities encompassing various aspects of shrimp farming. These agencies have set requirements concerning building permits, environmental protection, export shipping, import of live organisms, sanitary standards, and a host of other important matters. These requirements constituted a very significant problem for potential growers who were having difficulties just addressing the technical obstacles of constructing and operating shrimp farms. Growers reported especially difficult problems dealing with Customs officials.[324] Industry officials assert that PROEXPO has helped growers deal with Government agencies and hope that INPA will also help alleviate some of the administrative difficulties.

B. PROEXPO

The development of Colombia's shrimp culture industry has been achieved primarily by private investors, but the Colombian Government has played an important promotional role. Colombian officials in the early 1980s were concerned with the country's worsening trade balance. The Betancur Administration in 1982 initiated a study to assess potential small or non-traditional industries which could be promoted to increase export revenue. Administration officials ranked shrimp aquaculture as the activity with the greatest promise.[325] Government officials not only recognized the potential to generate export revenue, but also the industry's potential to create relatively well paying jobs in depressed rural areas. As a result, PROEXPO in 1984 assigned shrimp aquaculture its number one priority for promotion in the 1984-90 Plan General de las Exportaciones Colombianas.

PROEXPO implemented a comprehensive program to promote shrimp culture in Colombia.[326] The agency offered legal assistance dealing with some of the major problems confronting growers: complicated Government regulations, export tax rebate certificates (CERT), technical support, and credit.[327] PROEXPO assistance in obtaining credit proved critical for many projects. The agency was helpful in obtaining low interest loans with only small down payments. PROEXPO required qualified investors to obtain investment capital for purchasing the actual farm site through normal commercial bank loans. Once the land was acquired and a project planned, PROEXPO offered financing for up to 90 percent of project costs, to a maximum of $1 million. The terms were set at 14 percent interest over 5 years with a 2-year grace period.[328] (See: "XVII. Credit.") PROEXPO credits required INDERENA approval and the assurance of bank guaranties. PROEXPO also sponsored technical and marketing missions abroad.[329] The Government changed the investment law to attract foreign capital. Other Government agencies also assisted the industry. The Government in May 1984 announced that wholly foreign-owned firms could engage in export oriented activities and specified shrimp aquaculture as one such activity.[330] The Colombian Institute for Agrarian Reform (INCORA) in 1986 obtained over $5 million in credits for shrimp culture projects from the World Bank.[331] The INCORA project was designed to help low-income farmers culture shrimp, but no details are available on the outcome of the project.

C. Regulatory system

Colombia has a complex regulatory system controlling land use and ownership and water use.[332] Even before the shrimp culture industry developed, the Government attempted to assist individuals and groups interested in aquaculture deal with the complex legal framework. The Government established the Rural Integrated Development Program in 1975 and the Programa Integral de Cuencas en Deterioro (PRIDECU) in 1977. These development programs reportedly assisted various groups in obtaining needed permits for fish culture projects. The Ministry of Agriculture regulates the development of uncultivated land for agricultural (including (aquaculture) purposes.[333] INCORA, a Ministry of Agriculture unit, regulates the development of unused land beyond the 50-m shoreline.[334] DIMAR issues permits allowing growers to use beaches and tidal land for aquaculture. DIMAR also grants permits for water usage.[335] Groups receiving permits are required to abide by a variety of regulations protecting mangroves and affecting aquatic and other renewable resources.[336] Access to water resources is controlled through a system of regional priorities assessing a variety of ecological, economic, and social factors.[337] The Ministry of Health requires that water used for aquaculture must meet certain quality standards and also maintains standards for pond effluent.[338]

Potential shrimp growers faced the same involved legal process to initiate aquaculture projects as fish farmers.[339] The necessary authorizations were required from the Colombian Government agencies mentioned above, especially INCORA, DIMAR, and INDERENA. The process to obtain those authorizations proved complicated and extremely time consuming. INCORA authorizations were needed as most farms were built on waste land that was not being used. DIMAR authorizations alone reportedly required 10 different procedural steps as well as a study of winds and tides similar to those required for oil drilling. Many of the INDERENA requirements duplicated the INCORA and DIMAR application process. PROEXPO assistance in meeting the complex application process proved extremely helpful to the industry.[340]

D. Apertura Program

ACUANAL is concerned that the Government's new Economic Opening Program ("Apertura") initiated in February 1990 may adversely affect the shrimp culture industry.[341] Industry groups have generally endorsed Government programs, especially the PROEXPO promotion projects, which played such a key role in the development of many farms. (See: "PROEXPO" above.)

Some growers are optimistic about the Apertura Program. At least one observer reports that industry groups are hopeful that the new free market policies of the current Colombian Government will reduce some of the complicated bureaucratic process which now impedes financial transactions.

Many industry leaders, however, are now expressing considerable concern with the new Apertura Program. Growers believe that a stable, long-term promotion program is important for the industry's future. Economic austerity measures included as part of the Apertura Program substantially reduce benefits offered to growers. PROEXPO is continuing to assist the industry. PROEXPO approved $9.2 million in working capital loans and $1.5 million in capitalization loans during 1990.[342] Data on 1991 loan disbursements are not available, but unconfirmed reports suggest a decline. Changes by PROEXPO in its support program have caused uncertainty among potential investors, although agency officials have stressed their continued support.[343] ACUANAL is concerned with interest rate increases, CERT cutbacks,[344] and loan guarantee reductions. ACUANAL President, Clara Maria Sanin Posada, maintains that these steps discourage development, creating "fear and uncertainly at a point when the industry is not yet fully mature."[345] Industry spokesmen seem especially worried about the changes in the CERT program.[346] Other observers concur that changes in the PROEXPO program are adversely affecting the industry's development.[347] One recent industry assessment suggests that the Government's new policies are costing the industry about 25 percent of their net income.[348]

PROEXPO officials recognize the industry concerns, but maintain that the Apertura Program was designed as a county-wide approach to Colombia's economic problems. The Government's policies are based on a careful assessment of overall national economic needs. Officials insist that the

Apertura Economic Program is a far-reaching, comprehensive approach to Colombia's economic problems, including actions affecting foreign trade, foreign investment, exchange controls, infrastructure, finance, tax, and labor matters. The overall objective is to promote economic growth by opening up the economy to private investment and initiative. Officials believe that the program will help Colombian firms develop a greater export orientation and improve their competitiveness.[349] Various industries will obviously be affected differently by the Program. Thus while growers will find reduced support in some areas, they may benefit from the Program's overall impact. Government officials strongly affirm their long-term support to economic growth and export enhancement.[350]

XVII. CREDIT

Credit has been a continuing problem for Colombian and other Latin American shrimp growers. The industry's development has generally coincided with the overall Latin American debt crisis. The contracting credit markets have adversely affected growers throughout the region. Many interested Colombian groups failed to obtain necessary start-up financing. Many which did were forced to close their farms when they encountered technical difficulties, unable to obtain adequate working capital to continue operations. The poor results achieved by the early growers tended to dissuade commercial banks from committing additional funds to this unproven new industry.

Growers could offer the banks little collateral. Even their land had little value. Many farms were built on land unsuitable for agriculture (salt flats, tidal land, and mangrove areas). Growers selecting sites on arable land found that once ponds were constructed, other economic activities were precluded. The construction of ponds, canals, and other facilities seriously complicated planting without costly regrading and demolition, thus seriously impairing their ability to offer land as collateral. In addition, the failure of a farm would make it difficult to sell, even to other growers. Any prospective purchaser would suspect that the failure could have been due to poor sight selection or pond design.

PROEXPO played a key role in breaking the financial bottleneck and helping new growers obtain start-up financing. (See: "XVI. Government Role.") PROEXPO had a particularly significant role in helping to finance projects from 1986-88, but has since curtailed its involvement. Growers have reported continuing problems obtaining adequate credit, especially since PROEXPO reduced its efforts.

The credit problem has been a major factor in the vertical integration of the industry.[351] Prospective growers had to seek financial backing from large Colombian companies and investment groups. As a result, almost all of the larger, more successful farms are associated with large Colombian investment groups.

The authors have no detailed information on foreign investment. Few foreign groups, however, appear to have equity participation in Colombian farms. In the beginning, the restrictive investment code of the Andean Pact discouraged foreign investment. Press reports indicate, however, that the Colombian Government eased restrictions on foreign groups investing in export industries.[352] This would open shrimp farming to foreign investment as most farms export almost all their harvest. Despite this step, few foreign investors have committed funds. The serious security problem may partially explain this reluctance.

ACUANAL reports that many Colombian shrimp farms are heavily indebted. The current debt situation has resulted from a variety of negative factors. **Investments** per ha are rising as growers turn to increasingly sophisticated semi-intensive systems. **Prices** in real terms on the international shrimp market are falling. **Subsidy** payments such as the CERT have been reduced by the Government. **Credit** is becoming more difficult to obtain for working capital. **Interest rates** are increasing. These factors combined with other problems[353] faced by growers are creating serious financial problems at many farms despite the improving yields. One analyst has expressed great concern with the liquidity and financial position of many farms.[354] ACUANAL reports that the industry is successfully addressing these problems, but urges the Government to ease credit restraints. ACUANAL would like loan terms changed to give growers a 4-year grace period after which repayment would be made over a 10-year period.[355]

XVIII. TECHNICAL CAPABILITY

Colombia currently has a very limited technical capability to support its aquaculture industry. Some question the Government's capability to adequately support the technical needs of the rapidly expanding shrimp culture industry. The country has only a few research institutes working on fisheries and, as a result, shrimp culture studies are a small part of their overall efforts.[356] Only a handful of researchers specialize in shrimp culture and have initiated shrimp culture studies.[357] This is not a criticism specifically aimed at Colombian officials and researchers. In fact, commercial shrimp culture is such a relatively recent development that researchers in even the most developed countries are just beginning to answer basic questions on nutrition, maturation, pathology, and other critical questions. The problem is significant in Colombia, however, as the country has traditionally given so little attention to fisheries and aquaculture that the fisheries research infrastructure is especially small. This does not, however, reduce the needs of Colombian growers who probably have a greater requirement for research assistance than growers in many other countries.[358] While a number of studies have been published, Colombian shrimp culture research is still limited and has only begun to address even the most fundamental industry needs. Few Colombians have advanced degrees with specialties focusing on shrimp culture. Only a small number of aquaculture training programs are available, none of which offer sophisticated courses designed for major shrimp culture specializations.

A. Research

Colombian and foreign observers are concerned about the small amount of aquaculture research conducted in Colombia. Available bibliographies of published studies suggest that formal research has been very limited, both on aquaculture in general and especially on shrimp culture. Many basic questions are not being addressed and some growers believe that much of the research being conducted is of limited practical use to them.

1. Programs

An effective research program would have to be financed and coordinated by the Colombian Government. The Government is sponsoring some work. INDERENA is the leading research institute and has funded a variety of studies, primarily at the Cartagena CIP. The Red Nacional de Acuicultura and COLCIENCIAS since 1985 have played an important role in coordinating the aquaculture research activities of the country's various research institutes.[359] The efforts underway, however, do not begin to meet the industry's needs. Not only is the current research inadequate, but it often does not address many of the more practical subjects that growers would find most useful. Given Government financial restraints it is unlikely to expect any significant Government research effort at this time.

Colombian academic institutions have found it difficult to finance often costly aquaculture work. Until recently the aquaculture industry was of limited economic importance and was given a low priority by both Government and industry groups. In addition, the aquatic environment often entails more costs in research than agricultural subjects. Researchers have had to struggle with limited budgets and facilities. One observer suggests that high Colombian import duties have been one factor in discouraging research.[360]

Existing biographies of Colombian research work, however, may give a somewhat misleading impression. One researcher warns that the paucity of published work is deceptive. He points out that much more research has been conducted by private groups, but the distribution has been extremely limited.[361] Much of the academic research that has been conducted in the public domain are thesis that have not been published or entered into data bases accessible to international or national researchers.[362] Such works are only available in the libraries of individual universities.

Currently some of the most valuable work is being conducted at individual farms. Several important companies, however, do not appear willing to make serious financial contributions to fund needed research. One observer insists out that the research needs are so large that no individual grower can seriously address them individually. There also does not appear to be a close relationship between growers and researchers. Many growers appear reluctant to cooperate closely in any Government coordinated research program.[363] Other growers are skeptical that academic research will prove useful to them.[364] Relatively few investors seem troubled by the limited research currently underway or appear to be willing to finance serious studies, even on priority subjects. In addition, several important companies have recently allowed contracts with foreign consultants to lapse. This appears to be reducing Colombian access to foreign technology at a critical point in the industry's development. One unforseen consequence of the decision by growers to allow technical contracts to expire may be reduced sharing of information among growers. One difficulty reported in Colombia was the initial reluctance of growers to share information with their colleagues. This changed dramatically when several key growers contracted the same U.S. consulting firm, thereby facilitated the sharing of technical findings.[365] It is not yet known if Colombian growers will now continue to share information on their own or will try to closely guard results.

ACUANAL has made some effort to promote research, but its resources are limited. One observer maintains that an industry financed research program could make an important contribution. He points to a research program financed and controlled by an important agriculture industry group in Colombia, the Centro de Ivestigacion Caña (CENICAÑA) which focuses on improving the productivity of the sugar cane industry. CENICAÑA is financed by a small levy (0.55 percent) on cane production. A similar program could be used to supplement Government research funding, but few growers appear to be enthusiastically supporting the proposal.

2. Subjects

Most observers agree that research work needs to be expanded significantly. The industry's research needs are enormous. Growers report that much practical research is needed on some very difficult problems. One assessment of the Colombian shrimp culture industry points out the need for extensive research, especially on hatchery maturation.[366] Other pressing needs include work on shrimp growout, nutrition, and pathology. One of the most critical needs is for expanded work on shrimp nutrition, especially improvements of feed conversion ratios. Many growers are especially interested in suggestions on dealing with the declining yield during the dry season (December through April). Similar problems are reported by Central America growers.[367] One observer stresses the need for work on pond bottoms and predators.[368] Other observers insist that disease research should be given greater priority.

3. Research Institutes

Colombian researchers have conducted studies on both freshwater aquaculture and mariculture. The focus has until recently been almost entirely on freshwater species, mostly finfish. The growing commercial importance of the shrimp culture industry, however, has resulted in expanded attention to marine species.

a. Freshwater

Colombian aquaculture researchers have focused primarily on freshwater species such as trout, carp, tilapia, mullet, a variety of indigenous species (especially cachama), and ornamental fish.[369] Freshwater aquaculture research has been conducted by the Regional Corporations (CAR, CVC, CVS, and CRQ), CORTOLIMA, INDERENA, Caldas University (Centro de Invesigación Piscícola)[370], Instituto Tecnico Salesiano, Universidad de Cordoba, the Universidad Tecnologica del Magdalena, the Universidad Tecnologica de los Llanos Orientales, CORPOCESAR, and CORPOURABA. Several private companies have also conducted important research, including the Federacion Nacional de Cafeteros, Trucha de los Andes, CASTALIA, Acuicultura, Las Brisas, and COLAPIA.[371] Some of the work has been funded by Fondo de Fomento Agropecuario (FONADE).

Almost all of the above research groups have focused on finfish, but a few groups have also done some work on freshwater shrimp:

CENIPACIFICO: The Centro de Investigaciones Marítimas y Tecnológicas del Pacífico (CENIPACIFICO) has reportedly worked on freshwater shrimp, including a pilot study in the Cauca Valley.[372]

CVC: The Corporación Autónoma Regional del Cauca (CVC) has done some work on freshwater shrimp.

INDERENA: INDERENA is one of the most important Colombian research institutes working on aquaculture.[373] INDERENA's limited freshwater shrimp research has been conducted at its Cartagena center (IVERENA) and at the Estación Piscócola Alto Magdalena. Some of this research has been supported by FAO[374] and the Taiwan Government.[375]

Universidad del Valle (UV): The UV is one of the principal Colombian research institutions working on freshwater shrimp. University researchers have evaluated different species of *Macrobrachium* and

continue to assess other species.[376] The UV is currently building a freshwater shrimp hatchery and hopes to eventually produce commercial quantities of postlarvae.[377] UV researchers report important technical advances are being achieved.[378] Researchers are also working at shrimp farms trying to develop profitable methods for shipping live product.[379]
Other groups: Information on freshwater shrimp culture research by other Colombian institutions is unavailable.

b. Marine

Mariculture research has been even more limited, perhaps reflecting the small Colombian marine fishery. INVEMAR, CENIPACIFICO, CIMUR, CVC, CVS, and INDERENA have conducted most of the mariculture research. Much of the work has focused on shrimp as it constitutes about two-thirds of Colombia's overall cultured harvest.
INVEMAR, COLCIENCIAS's marine research center is one of Colombia's leading mariculture centers.[380] INVEMAR has conducted mariculture research since 1978 when it initiated an oyster culture project in la Ciénaga Grande de Santa Marta. INVEMAR implemented a much expanded mariculture program in February 1988. The INVEMAR program was designed to develop appropriate technologies to produce seedstock, primarily marine shrimp and mullet. The first stage of INVEMAR's program has focused on nutrition and reproduction. The nutrition work has concentrated on native microalgae, rotifers and *Artemia*. The reproduction work has concentrated on the spawning and maturation of *P. schmitti*. Specific studies have been conducted on the biology and ecology of Caribbean shrimp species (*P. schmitti*, *P. duorarum* and *P. brasiliensis*); maturation, spawning, and pl production (species other than *P. vannamei*); and bacteriological ecology and its influence on larval nutrition and pathology.[381] INVEMAR has a small laboratory for studies on *Artemia* and algae.[382]
INDERENA has three Centros de Investigaciones Pesqueras (CIPs) that have worked with shrimp culture. The Cartagena CIP has worked with *P. vannamei, P. brasiliensis,* and *P. schmitti*, focusing on diet and growout methods.[383] The Tumaco CIP has worked with *P. vannamei* and *P. stylirostris*, focusing on growout and harvest methods and collection of wild postlarvae. The Repelón CIP has worked with *P. vannamei* in freshwater.[384]
CENIPACIFICO: This group reportedly does some work on mariculture, but no details are currently available.
CIM: Several Colombian research institutes are currently cooperating to found a new Centro de Investigaciones Marinas (CIM) at Bahía Malaga. The cooperating institutes are reportedly CENIPACIFICO, DIMAR, CVC, and the Universidad del Valle. CIM will reportedly have an important mariculture program.[385]
CIMUR: CORPOURABA's research center at Turbo, has worked on both marine shrimp and oyster culture. Their marine shrimp work has covered growout methods and collection of wild postlarvae.
CVC: The CVC has a small laboratory and is conducting studies on reproduction and growout.[386]
CVS: The Corporación Autónoma Regional del los Valles del Sinú y San Jorge (CVS) has a research station with an experimental hatchery and since 1990 has been conducting research on marine shrimp.[387]
UV: While the UV has focused primarily on freshwater shrimp, they have also conducted some work on marine species.

B. Training/technical assistance

Shrimp aquaculture training opportunities are extremely limited in Colombia. Several universities and other groups offer aquaculture courses, but they are almost entirely limited to freshwater finfish. The principal institutions know to the authors are:
The **University of Bogota** (UB) has a School of Marine Sciences and Food Technology which trains biologists and limnologists. UB is currently the only Colombian academic institution offering a marine biology degree.[388] UB aquaculture activities have included some work on shrimp nutrition, growout, pond productivity, diseases, and other subjects.

The **Servicio Nacional de Apredizaje** (SENA) helps to train aquaculture technicians. Part of is efforts include both freshwater and marine shrimp programs.[389]
The **University of Caldas** has a School of Veterinary Medicine with a fish culture section. It works with the SENA to promote small-scale aquaculture.
The **University of Cordoba** works with CVS and has a School of Aquaculture Technology.
The **University of Magdalena** trains fishery engineers.[390]
The **Universidad Nacional** has a post-graduate program which it conducts in cooperation with

INVEMAR.

The **Universidad Nacional de Colombia** offers a basic fish culture course for biology students.[391]

INDERENA provides aquaculture courses to extension agents of other institutions.

Growers report that their biologists have received most of their specialized shrimp training on the job. One Colombian observer reports that university training for biologists is "very deficient."[392] Several have worked and gained experience at Ecuadorean farms. Others have received valuable insights from other biologists and foreign consultants at the farms which have contracted consulting groups. Only one farm, however, is known to have any regular training program for their professional staff.[393]

The shrimp culture industry is in great need of training and extension services for growers. One Government official believes that there is a special need for training or technical assistance in the areas of nutrition, disease, and pl management.[394] Several observers have mentioned that trained personnel in both farm and hatchery management are not available in adequate numbers.[395] Given the industry's rapid pace of development, this shortage may become an increasingly serious problem. Growers report difficulties attracting skilled workers to the isolated farm sites.[396] One observer emphasizes the critical need to expand in-country training of Colombian technicians and estimated that 70-80 trained hatchery technicians, 250-275 biologists managers, and 3,000-3,500 skilled growout technicians will be needed by 1992.[397]

Colombia can probably improve its training efforts. Several universities are capable of offering adequate **basic aquaculture training programs**. Colombian universities are already increasing programs for training aquaculture technicians which is providing growers access to an expanding pool of technicians. For the time being, however, sophisticated knowledge of shrimp will probably have to be obtained at foreign universities and through experience working at hatcheries and farms. The country's ability to initiate an effective **extension service** is questionable. The Colombian Government would probably find it difficult to launch an effective extension service for shrimp growers. Some Government officials question the justification to use appropriated funds when commercially successful farms could hire consultants. Not only are funds limited, but the Government would find it difficult to hire and retain highly qualified staff. Competent technicians command much higher salaries in the private sector than the Government can offer. Colombian universities could probably retain competent staff by directly engaging in **consultancies** or allowing their staff to do so. This could generate funds needed to retain highly skilled researchers.

Foreign technical assistance has played an important role in helping Colombian growers develop what is arguably the most efficient industry in Latin America. The foreign assistance has been critical given the limited capability of Colombian research groups and the small numbers of Colombians with advanced technical training in fisheries or aquaculture. Foreign consulting firms have played a major role in the development of Colombia's increasingly productive semi-intensive farms.[398] Consultants have been active in farm design, growout technology, and hatchery operations. Despite their successes, unconfirmed reports suggest that several growers are allowing consultancies to lapse.[399] One grower claimed that his consultant was learning more at his farm than he was learning from him. Some believe that foreign consultants can now be replaced with Colombian biologists. Other observers believe that growers are making a serious mistake in cutting back on consultancies at this time. Significant technical issues are still largely unresolved. In addition, Colombian growers face a more competitive international market and steadily rising world production. Growers must compete with low-cost Ecuadorean producers and increasingly efficient Asian competitors.

Information on domestic consulting firms is very limited. One company, INMARES, is known to have played an important role in assisting several hatcheries.[400] (See: "XI. Postlarval Supply: C. Domestic hatcheries.") The authors have, however, no further information on domestic consultants.

Colombian growers have obtained technical assistance in several different countries. The single most important source has been private consulting groups in the United States.

Ecuador has played a role in the development of the Colombian industry. Several Colombian biologists have worked at Ecuadorean farms, gaining valuable experience. Various companies have also contracted with specialists in Ecuador.

The **European Community** (EC) is planning a project to use satellite imagery in identifying potential sites.[401] The EC has a regional fishing technical cooperation project for Peru, Ecuador, and Colombia (ALA REG 8721).[402] The EC contribution totals $6 million and includes some shrimp culture activities, although few details are available on the activities in Colombia.

France, through France-Aquaculture, has assisted CAMCAR with both growout and hatchery work.

IOCARIBE is sponsoring an assessment of the impact of the shrimp culture industry on the mangrove ecosystem. A Swedish university is cooperating with the project.[403]

Taiwan has provided some assistance,[404] working primarily with INDERENA in its freshwater shrimp work, but also completing some work on marine species.[405] This research has been important, not only because of the results, but also because of the training opportunities for Colombian researchers, some of whom have emerged as the country's leading shrimp culture experts.

United States private consulting groups have been especially active in Colombia. The most important work has been conducted by Tropical Mariculture Technology (TMT) which has worked in Colombia since 1984. TMT has managed eight farms and a hatchery and has done consulting work for four other farms. Granada has worked with Colombiana de Acuacultura. RPI International has worked with the Postlarvas del Caribe hatchery. Only limited assistance has been obtained from U.S. Government agencies. The U.S. Agency for International Development is helping to fund a small project conducted by the Smithsonian Institution to study the fauna found in pond bottoms along the Caribbean coast.[406]

XIX. DISEASE

Some Colombian observers are especially worried about possible disease outbreaks like the ones that have occurred in Asia.[407] Disease has probably not been a major problem in Colombia to date, but the authors know of no good published summary assessing the situation. Knowledge of shrimp diseases worldwide is so limited that a variety of problems are almost certainly not being diagnosed.[408] As Colombian growers expand the area farmed and as growers turn to increasingly intensive methods, problems with disease are increasingly likely. The industry's heavy reliance on foreign hatcheries makes Colombia especially susceptible to imported pathogens. The proliferation of small, "backyard" hatcheries is a further concern. Limited quality control capability at many hatcheries, particularly the "backyard" hatcheries, poses some concerns, especially given the wide-spread importation of nauplii. The potential for spreading disease organisms because of shipments to widely diverse locations is significant and could result in serious future problems. (See: "XI. Postlarval Supply: Hatcheries")

Colombian institutions have conducted some research on disease. The effort is, however, just beginning to address a very difficult, highly technical subject. Few Colombian biologists have a sophisticated knowledge of shrimp pathogens. Colombian students are just beginning to specialize in shrimp pathology. Only a few Colombian academic institutions have demonstrated any interest in the subject. The **Universidad de Bogota** (UB) has a branch in Cartagena where students complete the last two years of their degree work in marine biology. The UB reports that some in-depth thesis work has been conducted by these students and they have gained the notice of Colombian shrimp farmers.[409] In addition, **INVEMAR** has conducted some limited studies.[410] **INDERENA** has also done some work.[411] The country is, however, clearly unprepared to deal with any major disease outbreak.[412]

XX. SOCIAL IMPACT

The Colombian shrimp culture industry is having an impact on the economies of the rural areas where the farms have been built. Some companies point with pride to substantial job creation.[413] The industry has created employment in many economically depressed areas which previously offered few job opportunities. The actual number of jobs at the farms, however, is limited. The industry is not labor intensive; only about 0.5-0.8 workers are needed per ha of pond area.[414] One observer estimates that the industry has created direct jobs for about 4,000 workers in rural areas.[415] The industry has also expanded job opportunities in support industries. Support industries have grown in the Cartagena area, and to a lesser extent around Tumaco. About 2,000 persons are currently employed in support services, primarily in urban areas. The industry's expansion has also created opportunities for merchants and other small businesses. In addition, the farms have made it economically feasible to bring a variety of public services (roads, electricity, health clinics, education potable water, and telephones) to previously isolated communities. Given the scale of development planned if current expansion continues in the 1990s, the shrimp culture industry could well develop into one of the most important economic activities along both coasts and play a major role in regional development.

The shrimp culture industry, however, can have some negative economic consequences. Aquaculture entails converting a "multi-user/multi-use" resource into a "privately-owned single use" resource. Jobs are provided for farm workers, but in a capital intensive industry like shrimp farming, fairly large farms can be run with a relatively small number of workers. Extensive employment is created during the construction phase, but few workers are required for growout operations. Unlike Ecuador, artisanal pl collectors have had little success in Colombia, thus local artisanal fishermen have benefitted little. Some coastal residents may actually find their incomes impaired by aquaculture development. The cutting of large areas of mangrove forestry (such as in Ecuador) adversely affected those individuals dependent on the mangroves.[416] In some instances the residents find their livelihood threatened, because of having lost access to the mangrove products. There appears to have been less destruction to the Colombian mangroves.[417] Perhaps more important in the long run may be the impact of developing large areas of coastal land and estuaries. One Colombian author is concerned that the shrimp aquaculture industry is adversely affecting local food production.[418] The impact is still largely unknown in Colombia and other Latin American countries.[419] Conversion of coastal areas for pond culture may prove, however, to have a major impact on other important commercial species upon which artisanal and commercial fishermen are dependent. Other potentially adverse, but poorly understood, impacts may include the utilization and/or diversion of water resources, the construction of off-take structures, the discharge of pond effluent, the use of fertilizer and agricultural chemicals and medicines, and the introduction of exotic species and diseases.[420]

XXI. OUTLOOK

The overall outlook for the Colombian shrimp culture industry is excellent. The country's ideal growing conditions, extensive area suitable for development, supportive Government policy, increasing experience and technical sophistication, and involvement of some important Colombian financial groups are laying the foundation for what could become one of Latin America's most successful shrimp culture industries. These factors may enable Colombia during the 1990s to emerge as a major producer of cultured shrimp. Achievements to date have been impressive for a country which did not have any commercial shrimp culture operations as recently as 1983. Reported yields are in many cases two or three times higher than those achieved in many other Latin American countries, although production cost data to fully evaluate those yields is not available. Such high yields are enabling growers to achieve impressive harvests from a still modest pond area. Growers are now reporting steadily expanding harvests. From minimal harvests in 1985, growers harvested 6,000 t in 1990 and exported over $30 million of shrimp. Industry sources project that 1991 will be another good year, with harvests that may approach 10,000 t and exports total over $50 million. Further major increases will almost certainly be reported during the 1990s, although the extent of those increases is difficult to project because it will be affected by a range of variables including world market trends.[421] Current trends and available area suggest, however, that Colombian growers may be able to harvest 30,000 t by the year 2000. Some other projections are even more optimistic. While such projections are only speculative at this stage, many observers are extremely optimistic about the industry's future and are convinced that Colombia will maintain its position as the region's second leading cultured shrimp producer.

Several factors may impair the ability of Colombian growers to develop the country's potential and to sustain the rapid growth achieved in the past few years. The most serious concerns are currently:

Feed: Some Colombian growers point to the need for higher quality feed as the industry's most significant problem. Feed companies maintain that they already produce high quality feed, but growers often order lower grade feed because it is less expensive. Obtaining adequate feeds at acceptable prices may be the major problem faced by growers in the 1990s. The feed question will become increasingly serious as growers continue shifting to high density growout methods to improve yields.

Research: The extremely limited research effort conducted thus far appears inadequate for an industry which could gross \$0.2 billion by 2000.[422] The increasing shift to more sophisticated, high-yield methods is creating greater demands for research to support the industry. Colombia's small fisheries/aquaculture research infrastructure may have difficulty coping with the needs of the expanding shrimp culture sector without a major industry support program to supplement Government funding. Reported cutbacks on foreign consultancies could impair Colombian access to foreign research.

Pl supply: Obtaining adequate supplies of postlarval seedstock has been the major impediment to the development of shrimp culture in many Latin American countries. Early Colombian growers reported similar problems obtaining postlarvae. Some reports suggest that this is still a serious problem.[423] Other reports provide more optimistic assessments of the supply situation,[424] but growers still cite substantial seedstock costs. Colombian growers appear to be obtaining adequate seedstock, but are dependant on imported nauplii. This puts the Colombian growers, however, in a vulnerable position. Anything which disrupts the imported pl/nauplii supply (for example, seasonal or climatic fluctuations in Panama or Ecuador) could have a devastating impact on Colombian growers. Other observers are less worried, pointing to expanding hatchery industries in Panama and other countries resulting in both increasing and more stable nauplii production. Colombia's hatchery industry should be able to supply increasing quantities of pl and the availability of pl is not likely to limit the industry's expansion during the next few years. The long-term situation, however, is less clear.

Trained personnel: The major expansion envisioned by the industry will create a significant demand for trained hatchery and growout personnel. Current in-country programs are not training adequate numbers of personnel with even basic degrees, let alone the skills needed for sophisticated growout and hatchery work.

Disease: Colombian growers stocking at high density to increase yields are likely to face greater disease problems then faced elsewhere in Latin America where extensive methods using lower stocking densities are more common. Colombian researchers have not seriously addressed shrimp pathology and Colombian growers will be forced to rely on foreign technical assistance.

Economic/political situation: The Colombian Government, through its Apertura program, is addressing many of the economic policies which have restricted investment. Growers are concerned about some aspects of this policy, especially changes in the CERT program. Other economic and political factors pose problems for growers, including infrastructure needs, image problems in the United States and other export markets, and the volatile security situation. Growers not only continue to experience difficulty in obtaining credit, but also are faced with rising interest rates. Some observers are very concerned over the substantial debt burdens at many farms.

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ENDNOTES

SECTION I. (Capture Fishery)

1. Law 23 (1990). Details on the basic provision of the law are available in Milan Kravanja and Dennis Weidner, "Colombian Fishery Developments," *International Fishery Reports* (IFR-90/23), April 8, 1990.

2. Various companies in recent years have begun to develop other fisheries. Tuna is becoming increasingly important and Colombia has become one of the major Latin American exporters. Blas Elias, Director, Division of Planning and Development, Vikingos, personal communications, July 15, 1991.

3. All quantities in this report, except for trade (import and export) data, have been converted to live weight equivalencies to make it possible to compare available catch, harvest, yield, and cost of production data. Difficulties were encountered in making these conversions, however, as some authors did not clearly specify if they were reporting tail or whole data.

4. Rafael Vesga F., *Casos de Exito de Desarrollo en Colombia: Las Exportaciones de la Camaricultura*, FEDESARROLLO, November 1990, p. 31.

5. A good description of the Caribbean coast shrimp fishery is available in Victor Piñeros and Pablo Siegert, "La pesquería de camaron en el Caribe Colombiano," *Informe* (Museo del Mar), 1981, No. 30.

6. INDERENA stands for the Institute for Development of Renewable Natural Resources and the Environment. It is the government agency responsible for fisheries and other renewable natural resources. It is organizationally part of the Ministerio de Agricultura. The Colombian Government made basic changes in the fisheries administration structure in 1990. INDERENA is reportedly being replaced with a new agency. Magnus Magnusson, personal communications, November 14, 1989.

7. U.S. Embassy, Bogota, February 6, 1990.

8. U.S. Embassy, Bogota, February 6, 1990.

9. A detailed stock assessment was conducted in 1970. H.J. Squires, *et. al.*, *Resultados preliminares de los cruceros 6901-6906 con el buque camaronero comercial fletado "Cacique,"* Estudios e Investigaciones (INDERENA), No. 2, 1970. A good historical review of the Pacific coast fishery is available in O. Mora and O. Barona, "Evaluación preliminar de la pesqueria de camarones en el Pacífico colombiano," *Divulgacion Pesquera* (INDERENA), 1979, Vol. 14, No. 1. A more current review of both the commercial and artisanal fishery is available in O. Mora Lara, "Analisis de la pesca de langostinos (*Penaeus [Lithopenaeus] occidentalis* Street) efectuada por la flota camaronera de Buenaventura y el transmallo 'electronico'," *Trianea* (Act. Cient. Tecn. INDERENA), 1988, Vol. 1, pp. 193-207.

10. The artisanal fishermen operating in the estuaries and other inshore waters take primarily juveniles. This may be affecting the overall yield of the fishery. Mora, *op. cit.*

11. U.S. Embassy, Bogota, May 13, 1991.

SECTION II. (Aquaculture Industry)

12. Ricardo Alvarez-Leon, INVEMAR, "El desarrollo de la maricultura en Colombia," *Revista Latinoamericana*

de Acuicultura, September 1982, No. 13, pp. 9-19.

13. A good review of Colombia's overall aquaculture program is available in Juan Patricio Molina, Unidad de Desarrollo Agrícola, Departamento Nacional de Planeación, "La Acuicultura en la Planificacion del Desarrollo Agropecuario," in *Memorias III Reunion Red Nacional de Acuicultura*, Cali, October 31 and Calma, November 1-3, 1989, pp. 25-36.

14. "P500 Millones vale la reactivacion de la pesca, "*El Espectador*, October 12, 1986.

15. FAO, "Aquaculture Production, 1986-1989," *FAO Fisheries Circular*, No. 815, Rev. 3, p. 103.

SECTION III. (Species)

16. A glossary of shrimp species which occur off Colombia is available as appendix B2.

17. A dated, but detailed assessment of Caribbean stocks is available in COPESCOL, "Investigacion preliminar sobre la pesca del camaron comercial en el Caribe Colombiano con algunas anotaciones biologicas sobre el *Penaeus duorarum notialis* Canet. Zone 1 Golfo de Uraba a Puerto Colombia," Bogota, 1969. More recent data is summarized in Manuel Garcia V. and Maria Victoria Ramirez, "Evaluacion de los Recursos Camaroneros en el Caribe Colombiano," INDERENA, May 1982.

18. Reports differ somewhat as to the dominant *Penaeid* species in the Pacific-coast trawler catch.

19. INDERENA has been the most active research group. See, for example, Luis E. Martinez Silva, David Osorio Dualiby, and Marta J. Torres V., "Estudio Comparativo del Comportamiento y Desarrollo en el Cultivo de Camarones Marinos del Pacifico y el Caribe Colombiano con Enfasis en *Penaeus stylirostris* (Simpson)," *Trianea* (Act. Cient. y Técn. INDERENA), Vol. 3, 1989, pp. 7-25. Alvarez-Leon, "El desarrollo," *op. cit.*, pp. 10-11. For an inventory of research studies conducted by CENIPACIFICO, CIP/INDERENA, CORPOURABA, CVC and the Universidad del Valle, see COLCIENCIAS, "Bases para el inventorio del potencial cientifico-tecnologico marino en Colombia," *Año Nacional de la Ciencia y la Tecnologia: 1988*, 1989, pp. 138-141

20. Jairo Maldonado H., Martha J. Torres V., Luis E. Martinez S., Bertha C. Renteria de M., and Isabel Borrero M., "Analisis de la interaccion de camaron marino *Penaeus vannamei* del Oceano Pacifico, respecto a las especies nativas del Atlantico Colombiano *Penaeus schmitti, Penaeus notialis*, y *Penaeus subtilis* en confinamiento," INDERENA/CIP Cartagena, unpublished study, December 1984.

21. See for example: Alba Iddalia Mosquera M. (Universidad del Valle del Cauca) and Luis E. Martinez Silva (INDERENA/CIP-Cartagena), "Experiencias de aclimatacion de camaron marino (*Penaeus vannamei*) al agua dulce," *Investigaciones Marinas y Acuicultura en el Caribe Colombiano*, INDERENA, August 1989; Luis E. Martinez Silva (INDERENA/CIP), Pilar Dorado Longas (INDERENA/CIP-Repelón), and Martha J. Torres Virviescas (INDERENA/CIP-Cartagena), "Cultivo Experimental de Camaron Marino (*Penaeus vannamei*, Boone) en agua dulce," *Investigaciones Marinas y Acuicultura en el Caribe Colombiano*, INDERENA, August 1989; and Luis E. Martinez Silva (INDERENA/CIP), Pilar Dorado Longas (INDERENA/CIP-Repelón), and Martha J. Torres Virviescas (INDERENA/CIP-Cartagena), "Comportamiento de desarrollo del camaron marino (*Penaeus vannamei*, Boone 1931) cultivado en agua dulce," *Investigaciones Marinas y Acuicultura en el Caribe Colombiano*, INDERENA, March 1990.

22. Dr. Baxter points out that the NMFS Galveston studies were conducted at the postlarval stage. Neil Baxter, Galveston Lab (F/SEC6), NMFS, personal communications, May 21, 1991.

23. Sanin, personal communications, *op. cit., September 11, 1990.*

24. Much of the research deals with both appropriate species, *P. vannamei* and *P. stylirostris*. Jaro Maldonado H., Martha J. Torres V., Luís E. Martínez S., and Raul Remolina C., "Experiencia de transplante de camarones marinos (Género *Penaeus*) de Tumaco (Oceano Pacifico) a Cartagena (Mar Caribe) INDERENA/CIP Cartagena, unpublished study, 1983-84 and other studies by Maldonado listed in the sources section.

25. Martínez, Dorado, and Torres, *op. cit*, Mosquera y Martínez, *op. cit., and Martínez Silva, Luis E, and Martha J. Torres V., and Pilar Dorado Longas. "Comportamiento de desarrollo del camaron marino (Penaeus vannamei*, Boone 1931) cultivado en agua dulce," *Investigaciones Marinas y Acuicultura en el Caribe Colombiano*, INDERENA, March 30, 1990.

26. Sanin, personal communications, *op. cit.*, June 7, 1991.

27. Henry C. Clifford III, Tropical Mariculture Technology, personal communications, April 4, 1991. Other observers believe that adequate *P. stylirostris* pl could be collected, but no one has yet acted to initiate a commercial collection activity. Dr. Paul D. Maugle, "Penaeid Shrimp Culture in Colombia," report prepared for PDM & Associates, Norwich CT, July 1989, p. 9.

28. Maugle, *op. cit.*, p. 15-18. As feed is the single most important cost factor at semi-intensive farms, the use of higher-quality and thus more costly feed can significantly increase overall production costs. See "Feed."

29. Most U.S. importers do not discriminate between *P. vannamei* and *P. stylirostris*. There appears to be little differences in, for example, taste and texture between the two species, although *P. stylirostris* does grow to larger sizes. A few U.S. importers, however, insist that the *P. stylirostris* be removed from *P. vannamei* packs, basically for aesthetic reasons. Removing the *P. stylirostris* (which have a small blue tip) gives the pack a more uniform look. William Antozzi, NMFS Marketing Specialist, personal communications, May 7, 1991.

30. Henry von Prahl and Marcial Gardeazabal, Camarones SEL, "Commercial Culture of Blue Shrimp (*Penaeus stylirostris*, Simpson) in Colombia," unpublished paper.

31. Clifford, *op. cit.*

32. Vesga, *op. cit.*, pp. 44-45.

33. Clara María Sanín, "La Industria Acuicultora en Colombia," *Red Acuicultura Boletin*, Vol. I: 1, July/December 1987, pp. 3-4.

34. See for example, Martha Jeannette Torres V. (INDERENA/CIP-Cartagena) and Luis E. Martinez Silva (INDERENA/CIP-Cartagena), "El Camaron Blanco (*Penaeus schmitti* Burkenroad, 1936) del caribe colombiano como alternativa en la acuicultura," *Investigaciones Marinas y Acuicultura en el Caribe Colombiano*, INDERENA, July 1988 and Ting Lang Huang, Jia-Jinn Chiu, Mao-Tsung Huang, Chiu-Yiang Jiu, Raul Remolina C., Christian de Nogales, Hernando Cardenas, Martha J. Torres V., Rodrigo Valencia, and Luis E. Martinez S., "Avance sobre el analisis comparativo de crecimiento entre dos especies de camarones marinos *Penaeus (Melicertus) duorarum notialis* (Perez Farfante) y *Penaeus (Litopenaeus) schmitti* (Burkenroad) cultivados en tanques experimentalis," INDERENA/CIP Cartagena, unpublished study, December 1978.

35. Clara María Sanin Posada, President, Acuanal, "La Acuicultura Segun el Punto de Vista de Acuanal," paper delivered at the Seminario de Pesca y Acuicultura, Banco Ganadero, February 27-March 1, 1991.

36. See for example, Juan Carlos Pedraza and Jorge Alberto Quintana J., "Evaluacion del crecimiento y sobrevivencia del 'camaron blanco' *Penaeus (Litopenaeus) schmitti* Burkenroad, 1936, con dos dietas cuya fuente complementaria de proteina es diferente," *Informe* (Museo del Mar), 1984, no. 30.

37. Harvey O. Persyn, President, Tropical Marine Technology, personal communication, October 8, 1990.

38. Luís E. Martínez S., Martha J. Torres V., Raul Remolina C., and Jairo Maldonado H., "Propagacion artificial y desarrollo descriptivo de los diferentes estadios larvales de camaron blanco *Penaeus* (Litopenaeus) *schmitti* (Burkenroad, 1936) del Caribe Colombiano," INDERENA/CIP Cartagena, unpublished study, 1982.

39. Clifford, *op. cit.* Another observer suggests that a few Caribbean growers are using *P. schmitti*, but she may be referring to the wild pl naturally present in the water and that inevitably penetrate into any Caribbean-coast pond. Clara Maria Sanin Posada, personal communications, *June 7, 1991.*

40. Albeiro Velez Gomez, Tecnologia Pesquera, Universidad del Choco, personal communications, February 12, 1991. Cuban researchers have concentrated on *P. schmitti* and are reportedly achieving successful harvests. Few details are available, but for a review of the industry see: Randolf Wells and Dennis Weidner, "Cuban Shrimp Culture," *International Fishery Reports*, in press.

41. Torres and Martinez "El camaron blanco" *op.cit.*

42. Jairo Maldonado H., Raul Remolina Caro, Martha J. Torres V., and Luís E. Martínez S., "Cultivo de camarones en estanques de tierra *Penaeus* (Farfantepenaeus) *notialis* y *Penaeus* (Farfantepenaeus) *brasiliensis*, en el Caribe Colombiano," INDERENA/CIP Cartagena, unpublished study, 1980 and Luís E. Martínez S., Isabel Borrero M., Martha J. Torres V., Jairo Maldonado H., and Bertha C. Rentería, "Cultivo del camaron pintado *Penaeus* (F) *brasiliensis* Latreille, 1817, a diferentes densidades," INDERENA/CIP Cartagena, unpublished study, December 1985.

43. H. Ting Lang, *et.al.*, "Desarrollo larval y obtencion masiva de postlarvas del camaron rojo (*Penaeus duorarum* Burkenroad), en el laboratorio," *Memorias del Segundo Simposio Latinoamericano de Acuacultura*, Vol. I, 1980, pp. 1641-1671 and Ting Lang, *et. al.*, "Avance," *op.cit.* The full scientific name is *P. duorarum duorarum*. Until 1939 most biologists grouped what we now refer to as *P. brasiliensis, P. d. notialis, and P. d. duorarum* together as *P. brasiliensis*. All three are now considered to be distinct species.

44. Luis E. Martínez Silva and Martha J. Torres V., "Notas sobre el mantenimiento del camaron rojo *Penaeus duorarum notialis* (Perez Farfante) y el camaron cafe *Penaeus aztecus subtilis* (Perez Farfante), en estanques experimentales," INDERENA/CIP Cartagena, unpublished study, 1976 and Maldonado, Remolina, Torres, and Martínez, *op. cit.* The full scientific name is *P. duorarum duorarum*.

45. Martínez and Torres, *op. cit.* and Luís E. Martínez Silva, Martha J. Torres V., Raul Remolina Caro, and Rodrigo Valencia, "Propagacion artificial y descricion del desarrollo larval del camaron comercial *Penaeus* (Farfantepenaeus) *subtilis* Perez Farfante, del Caribe Colombiano," INDERENA/CIP Cartagena, unpublished study, July 1980.

46. Luís E. Martinez Silva, "Distribucion biogeografica de camarones de agua dulce del genero *Macrobrachium* (Bate, 1968) (Crustacea, Palaemonidae) en el norte de Colombia," INDERENA/CIP Cartagena, unpublished study, 1973.

47. Alvarez-Leon, "El Desarrollo," *op. cit.*, p.10.

48. Luís E. Martínez Silva, "Desarrollo embrional y larval del camaron de agua dulce, *Macrobrachium acanthurus* Wiegmann 1836, bajo condiciones de laboratorio," INDERENA/CIP Cartagena, unpublished study, 1981; Luís Martínez Silva, A.M. Molinares, J. Villanueva, and D.A. Conroy, "Preliminary Observations on the Application of Nifurpirinol for the Control of Potential Disease Problems in *Macrobrachium acanthurus*," INDERENA/CIP Cartagena, unpublished study, 1980; Ting-Lang Huang, Jio-Jinn Chiu, Mao-Tsung Huang, Chi-Yiang Liu, Raul Remolina Caro, Rodrigo Valencia Rimie, Martha J. Torres V., and Luis E. Martinez S., "Descripcion de la metodologia empleada para la obtencion masiva de postlarvas del camaron de agua dulce *Macrobrachium acanthurus* (Wiegmann, 1836) en el laboratorio," INDERENA/CIP Cartagena, unpublished study, 1978; Luís E. Martínez Silva, "Biologia del camaron de agua dulce *Macrobrachium* acanthurus (Wiegmann, 1836) (Crustacea Palaemonidae) de la Cienaga de 'El Totumo' y su cultivo experimental en estanques,"

INDERENA/CIP Cartagena, unpublished study, 1975.

49. Ting Lang Huang, Jia-Jinn Chiu, Mao-Tsung Huang, Liu-Chih Yang, Raul Remolina C., Christian de Nogales, Hernando Cardenas, Martha J. Torres V., Luis E. Martinez S. and Rodrigo Valencia, "Obtencion de estados larvales y post-larvales del camaron de agua dulce *Macrobrachium carcinus* (Linnaeus) en el laboratorio," INDERENA/CIP Cartagena, unpublished study, 1978.

50. One study conducted by both INDERENA and FAO researchers assessed the possibility of shrimp/mullet polyculture. They concluded that culture of *M. acanthurus* was technically feasible Luís E. Martinez, Mario Pedini, and Michael S. New, "Cultivo experimental del camaron de agua dulce (Macrobrachium acanthurus) en la costa Atlantica de Colombia," *Divulgacion Pesquera* (INDERENA), Vol. 16, No. 5, 1981. Also reported in "Inland Fishery Development Program: Colombia," *FAO Aquaculture Bulletin*, January 1977, Vol. 8, No. 2, p. 31. Colombian researchers did some growout and larval work on *M. acanthurus* at Homerenas, Bolívar. Hanson and Goodwin, 1977, cited in Dallas Alston, "*Macrobrachium* Culture: Background, Current Operations, Future Aspects," *Contributions* (Department of Marine Science, University of Puerto Rico), Vol. 22, 1984.

51. See for example, Pan Jia Mo, Lu Zhi Guo, Yu Zi Hao, Luis E. Martinez Silva, David Osorio Dualiby, Martha J. Torres V., and Camilo A. Gomez R., "Tecnica de reproduccion artificial del camaron de agua dulce (*Macrobrachium rosenbergii*, de Man), *Investigaciones Marinas y Acuicultura en el Caribe Colombiano*, INDERENA, October 1987 and Pan Jia Mo, Lu Zhi Guo, Yu Zi Hao, Luis E. Martinez Silva, David Osorio Dualiby, and Martha J. Torres V., "Cultivo intensivo del camaron de agua dulce (*Macrobrachium rosenbergii*, de Man)," *Investigaciones Marinas y Acuicultura en el Caribe Colombiano*, INDERENA, September 1987.

52. Gabriel Ramos, "Programa desarrollo del Cultivo de agua dulce (*Macrobrachium rosenbergii*) en el Valle del Cauca," in *Memorias II Reunion Red Nacional de Acuicultura*, Neiva, September 1988, pp. 237-241.

53. The International Shrimp Research Center held Langostinos '89 in Cartagena July 4-8, 1989.

54. Henry von Prahl and Raúl Ríos, "Cria Escalonda del Camaron de Agua Dulce, *Macrobrachium rosenbergii*," in *Memorias III Reunion Red Nacional de Acuicultura*, Cali, October 31 and Calma, November 1-3, 1989, pp. 231-238.

55. Luz Edna Romero and Henry von Prahl, "El camaron rojo de rio, *Procambarus* clarkii, una especie promisoria?" *Red Acuicultura Boletin*, Vol. II: 1-2, July/December, 1988, pp. 11-115.

56. INVEMAR estimates that Colombian hatcheries require about 5 kg of *Artemia cysts per million postlarvae. Thus production of 1 billion pl would require 5 t of cysts.* INVEMAR thus estimates 1990 cysts demand in Colombia at about 4.1 t (for 0.8 billion pl). Newmark, *op. cit.* This roughly confirms the author's estimate of 4.5 t (for 0.9 billion pl) (appendix J).

57. Manuel Rozo C., "Proyecto Artemia: IFI-Concession de Salinas," *Red Acuicultura Boletin*, Vol. 1, No. 1, July-December 1987 and Ricardo Alvarez-León, Colombian shrimp researcher, personal communications, March 14, 1991.

58. Even using more conservative estimates, one INVEMAR official is convinced that at least 20-30 t of cysts could be produced. Frederico Newmark U., Coordinator, Mariculture Program, INVEMAR, personal communications, August 13, 1991.

59. Newmark, *op. cit.*

SECTION IV. (Area/Location)

60. Sources at INDERENA speculate that the potential pond area might be higher than the growers' estimate;

Orlando Mora Lara, Subgerente de Pesca y Fauna, INDERENA, personal communications, January 17, 1991.

61. Orlando Mora Lara, Subgerente de Pesca y Fauna Terrestre, INDERENA, personal communications, January 17, 1991.

62. Armando Hernández R., Coordinator, Regional Aquaculture Network (IDRC), personal communications, January 16, 1991. A recent Colombian study reports Pacific coast pond area at 39,500 hectares. Armando Hernández, Coordinator of the *Red Regional de Entidades y Centros de Acuicultura de America Latina*, personal communications, January 1991.

63. PROEXPO Washington Office, personal communication, May 20, 1991.

64. Toshida, presentation on "New Developments of Intensive Aquaculture and their Application in Colombia," 1991.

65. Various estimates are available from industry sources. Some will provide huge numbers based on the extensive Colombian coast and assuming that pond design can deal with soil and other physical constraints and that seawater can be used to supply the ponds. Other observers give relatively low estimates, based on the availability of sites with appropriate physical conditions located close to river deltas or other freshwater sources.

66. Horacio Rodriguez Gomes, Jefe, Division de Acuicultura, INDERENA, personal communications, July 29, 1991.

67. Velez, *op. cit.*

68. Vesga, *op. cit.*, p.36.

69. Maria-Isabel Ospina, Yvette Rusca, and Karen Sconiers, "Feasibility Study for Exporting Shrimp from Colombia into the United States," Tulane University, April 17, 1986, p.7.

70. Maragricola's plant is not yet operational and has been built primarily for the company's own pond harvest.

71. One observer reports transportation costs of $0.22 per kg to Buenaventura and $0.25 per kg from Buenaventura to Miami. Vesga, *op. cit.*, p.36.

72. Danigo, *op. cit.* and Sanin "Analisis," *op. cit.* A list of the new mills is not available, but one is being built by Cartagenera de Acuacultura.

73. *Asociación Nacional de Acuicultores de Colombia* (ACUANAL) data, provided by Armando Hernandez, personal communications, January 16, 1991.

74. Some reports have suggested higher areas of operating ponds. One report, for example, suggested that up to 2,900 ha of ponds were operational in 1990 (appendix G2). Pond area estimates are a subject of real confusion, yet are critical to determine in assessing the industry's capacity. The major source of data is ACUANAL which relies basically on the data supplied by individual growers. Sometimes the growers, for reasons of their own, report inflated figures to ACUANAL. Several farms operated under construction schedules established by the banks which have provided financing. Growers who fall behind in their pond construction program may be tempted to report that the ponds have been completed to avert action by their creditors. In other cases ACUANAL is adding responses by some farms which reported only pond area with others who reported total water surface (ponds, reservoirs, canals, etc.) or even total construction (offices, labs, dormitories, etc.).

75. Sanin, personal communications, *op. cit., September 11, 1990.*

76. Sanin, personal communications, *op. cit.*, June 7, 1991. For details on current expansion programs at individual farms, see "Companies."

77. David Larson, Cargill, personal communications, June 26, 1991.

78. Clifford suggests that considerable caution should be used in assessing Colombian data on pond area. Much of the available data from Acuanal and other sources may include roads, canals, dikes, buildings, and undeveloped property. He believes that the 1991 pond projection of 4,000 ha may in fact amount to only 3,000 ha of actual water surface area. Clifford, *op. cit.*

79. Martha Bernal de Mosquera, Subdirectora de Producción Pesquera, Ministerio de Agricultura, personal communications, April 4, 1991.

80. ACUANAL, "Analisis," *op. cit.*

81. Vesga, *op. cit.*, p.34.

SECTION V. (Growing Conditions)

82. Brazil and Mexico have longer coastlines, but much of their coast has temperate or semi-tropical climate which is less suitable than Colombia's tropical climate. Venezuela has a coastline roughly equal to the Colombian coast.

83. For details on Ecuador see Tom Revord and Dennis Weidner, "Ecuadorean Shrimp Culture," *International Fisheries Reports*, in press.

84. Maugle, *op. cit.* Alfonso Lozano, former INDERENA Aquaculture Director, was convinced that Colombia had the potential to surpass Ecuadorean harvests. "Higher Colombian Landings," *The Fish Boat*, August 1985, p.34.

85. In his initial survey, Mock expressed considerable concern with the heavy Pacific coast rainfall (118-394 inches annually) and concluded that only the Caribbean coast appeared to be suited for shrimp culture. Cornelius Mock, "Trip Report" September 16-25, 1980.

86. PROEXPO, "El Cultivo de Camarón en Colombia," *Colombia Exporta*, June 1989, pp. 25-31.

87. A good review of pollution levels from various sources is available in 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. 5-7.

88. Maugle reports that Cartagena Bay absorbs wastes from various unmonitored industries with hydrocarbon and heavy metal waste products. Maugle, *op. cit.*, p. 18-19.

89. Escobar and Barg, *op. cit.*, pp. 5-7.

90. Larson, *op. cit.*

91. Persyn, *op. cit.*

92. At first this had a somewhat negative impact on prices, but importers now appear less concerned as the underlying quality was not affected. Growers report that the yellow cast is strongest in new ponds and gradually fades as the ponds are used. Sol Barreto, Erin Sales, Personal communication, May 8, 1991.

93. The Swedish Center for Coastal Development and Management of Aquatic Resources (SWEDMAR) which is funded by the Swedish International Development Authority (SIDA) is supporting an IOCARIBE field study to assess the impact of the shrimp culture industry on the mangrove ecosystem. The study is being conducted by the Swedish Uppsala University and the Colombian Centro de Investigaciones Oceanográficas e Hidrográficas (CIOH) in the areas of Cartagena and the Golfo de Morrsquillo. "Minor Field Study on the Impacts of Shrimp Farming on Mangroves," *IOCARIBE News*, October 1991, p.2.

94. One observer believes that stable salinities at about 20 parts per thousand (ppt) are an especially important condition for optimal yields. Robert Rosenberry, Editor, *World Shrimp Farming*, personal communications, May 20, 1991. Another observer, however, reports that despite the more moderate rainfall, some Caribbean growers can experience relatively high salinities during the dry season. Larson, *op. cit.*

95. Opinions vary somewhat among Latin American shrimp farmers on tidal exchanges. Low tidal exchanges simplify pond management, but at least some observers believe that higher tidal amplitudes can be beneficial. Tides can be used for water exchange, mostly in extensive systems, to reduce energy costs associated with pumping. In addition, tidal exchanges can be helpful in flushing out pond effluent and bring in fresh water. This may become an increasingly important factor if disease problems become increasingly serious. Larson, *op. cit.* As Colombian growers have largely shifted to semi-intensive systems, most have discontinued the use of tidal fluctuations for water exchange. One observer reports that no Colombian grower uses tidal exchange for water exchanges. Clifford, *op. cit.*, July 12, 1991.

96. One observer reports that the conditions along Colombia's Caribbean coast enable growers to achieve yields 2 to 3 higher than Ecuador and the rest of Latin America. Philippe Danigo, France Aquaculture, personal communications, March 12, 1991.

97. Clifford, *op. cit.*

98. Pacific-coast sea surface temperatures from July to December are notably cooler than Caribbean temperatures. While average sea surface temperatures off Colombia are lower than along the Caribbean, they are higher than off Ecuador, especially southern Ecuador (appendix E).

99. Salinities can vary from 0-35 ppt. Maugle, *op. cit.*, p.8.

100. Clifford, *op. cit.* Currently the industry along the Pacific coast is limited to the Tumaco area. Soil conditions elsewhere along the Pacific coast are unknown.

101. See for example Gilma Stella Pedraza, Germán Márquez Calle, and Luis Carlos García Lozano, "Aspectos Hidro-Limnologicos en las Cienagas de Chucuri y Aguas Negras (Magdalena Medio, Colombia) Durante un Ciclo Anual," *Acta Biologica Colombiana*, Vol. I, No. 5, 1989, pp. 9-22.

SECTION VI. (Economic Conditions)

102. Many foreign observers immediately think of illegal cocaine earnings in connection with Colombia. The cocaine earnings are significant, but a variety of negative effects of those earnings probably counterbalance any positive impact. Much of the cocaine earnings, for example, remain largely outside the national economy and are banked in various Caribbean and European money-laundering centers. A more important factor may be that Colombia's traditional export products (coffee, coal, nickel, and oil) are being supplemented by a variety of non-traditional products, including cultured shrimp. Earnings from these non-traditional products are expanding rapidly, totaling $2.7 billion in 1990 or over 40 percent of total Colombian exports. U.S. Embassy, Bogota, May 14, 1991.

103. Early growers reported low land costs as the areas they identified for their farms were in many instances salt flats and other low lying land which at the time had little or no economic value. As the industry develops, however, land values will increase significantly. Current data on land values are unavailable.

104. U.S. Embassy, Bogota, May 14, 1991.

105. ACUANAL, "Analisis," *op. cit.*

106. Juan J. Plata C., "Acuicultura y Desarrollo Rural," *Acuicultura*, August 21-24, 1990.

107. U.S. Consulate, Barranquilla, April 24, 1989.

108. Sanin, personal communications, *op. cit, March 19, 1991.* Other local observers concur that the civil disorders will probably have little impact on the industry's development. A. Hernández, *op. cit.*

SECTION VII. (Companies)

109. A list of the major companies with addresses and phone numbers is attached as appendix A. Data on individual companies is available in appendices G1-3.

110. Maria-Edna Carrasco, Director-Strategic Planning, Bavaria, personal communications, May 21, 1982, and U.S. Embassy, Bogota, June 16, 1983. See also Mock, *op. cit.*

111. U.S. Embassy, Bogota, May 24, 1984.

112. Vesga, *op. cit.*, p. 108.

113. The hatchery reportedly produced 20-30 million pl in 1987, but no details are available on current production. *El Espectador*, April 30, 1988.

114. Pablo Andres Siegert Garcia, Gerente, Acuipesca, personal communications, May 14, 1991.

115. Agrosoledad release published by GLOBEFISH in "Value Added Seafood Products from Asia and Latin America, Anuga 91."

116. One researcher attributed the problem to an undescribed species of callianassid shrimp. The researcher speculates that the species presence should be beneficial, but on a short-term basis as a result of still unknown factors which can negatively affect growout operations. Rafael Lemaitre, Smithsonian Oceanographic Sorting Center, "Discovery of a new species of callianassid shrimp of commercial importance in *Penaeid* shrimp culture in northern South America," *World Aquaculture Society: 22nd Annual Conference & Exposition*, San Juan, Puerto Rico, June 16-20, 1991.

117. Persyn, *op. cit.*

118. Jose Vicente Mogollon Velez, Gerente General, Agrosoledad, personal communications, May 16, 1991.

119. Philippe Danigo, France-Aquaculture, item 15.11.27, *World Shrimp Farming*, November 1990, pp. 17-18.

120. Humberto Rodriguez Covo, Gerente Comercial, Camarones del Caribe, personal communications, May 30, 1991.

121. The feed mill is located at Mamonal and has the capacity to produce 2 t of balanced feed per hour. Hermes Figueroa, "Aporte a la Camaricultura Nacional," *El Universal*, June 5, 1992.

122. For details see "XI. Postlarval Supply: Hatcheries."

123. Harvey Persyn, President, Tropical Marine Technology, item 13.7.5, *Aquaculture Digest*, July 1988.

124. Joseph Massey and Bill More, Granada Corporation, "Granada Corporation," item 12.2.2, *Aquaculture Digest*, February 1987, p. 6.

125. Nicolas Del Castillo P., Gerente General, Colombiana de Acuacultura, personal communications, May 14, 1991.

126. GLOBEFISH, *op. cit.*

127. Elias, *op. cit.*

128. ACUANAL data, provided by A. Hernandez, *op. cit.* and Clifford, *op. cit.* Small differences exist between the two sources.

129. Jorge Ivan Rodriguez C., Manager, Compañia Camaronera Balboa, personal communications, June 18, 1991 and Oscar Velasquez Uribe, Deputy Manager, Compañia Camaronera Balboa, personal communications, August 21, 1991.

130. The company's tilapia exports will total about 440 t valued at $2.8 million in 1991.

131. Dan Cohen, Aquaculture Production Technology (Israel) Ltd., personal communications, June 5, 1991. Another observer provides slightly different yields, 16-20 t of tilapia in addition to 2-3 t of shrimp. Ziva Ra'anan (APT), Eran Lahav, Nir David (Fish Breeding Farm), and Francisco Perea (Maragricola), "The production of tilapia hybrids and *Penaeus vannamei* in a polyculture system," *World Aquaculture Society: 22nd Annual Conference & Exposition*, San Juan, Puerto Rico, June 16-20, 1991.

132. The plant was designed and equipped by the U.S. company Pisces Industries. "Tilapia Plant for Colombia," *Fish Farming International*, October 1991, p.5. Company officials report actually processing 635 t of shrimp in 1990 and project 1,000 t in 1991. Javier Betancourt Taborda, Subgerente de Operaciones, IDELPACIFICO, personal communication, November 21, 1991.

133. Juan Manuel Cardozo, Gerente Comercial, C.I. Maragricola, personal communications, May 15, 1991.

134. Germán Avila and Henry von Prahl, "Estudio de la viabilidad del transporte del camaron de agua dulce *Macrobrachium rosenbergii* vivo, en contenedores termicos a diferentes periodos de enfriamiento y analisis de la variacion del nivel de proteina muscular," in *Memorias III Reunion Red Nacional de Acuicultura*, Cali, October 31 and Calma, November 1-3, 1989, pp. 240. Henry Von Prahl and Fernando Sanchez, Unidad de biofiltracion para el desarrollo larval de *Macrobrachium rosenbergii*," *Red Acuicultura Boletin*, Vol. III: 2, May/August 1989, pp. 13-15 *and Avila and Von Prahl*, op. cit.

135. Vesga, *op. cit.*, pp. 104-105.

SECTION VIII. (Methods)

136. U.S. Embassy, Bogota, May 25, 1984.

137. Henry von Prahl, Biology Department, Universidad del Valle, "Cultivation of Shrimp in Cages as a Developmental Alternative," *Shrimp Aquaculture in the Caribbean Basin: Prospects and Constraints*, University of South Carolina/La Universidad Catolica Madre y Maestra, 1985.

138. Maugle, *op. cit.*, p.3.

139. ACUANAL, "Analisis," *op. cit.*

140. Sanin, "La Acuicultura," *op. cit.* and Clifford, *op. cit.*, July 12, 1991.

141. Various acclimatization procedures are used in Colombia. For details see Maugle, *op. cit.*, p.14.

142. Maugle, *op. cit., p.4.*

143. Harvey Persyn, "Tropical Mariculture Technology," World Shrimp Farming, January/February, 1992, pp. 5-6.

144. Sanin, "La Acuicultura," *op. cit.* and Sanin, personal communications, *op. cit.*, September 11, 1990.

145. ACUANAL, "Analisis," *op. cit.*, pp. 4-5.

146. An approximation can be computed by dividing the harvest (appendix F) by the pond area stocked in 1990 and 1991 (appendix G2-3). This suggests rough annual yields of 2.4-3.4 t per hectare.

147. Sanin, personal communications, *op. cit.*, June 7, 1991. Clifford suggests a somewhat lower range, but confirms that Colombia's top (semi-intensive) farms are all reporting annual yields exceeding 3.5 t per hectare. Clifford, *op. cit.*, July 12, 1991.

148. Jorge A. Assmus, item 13.9.21, *Aquaculture Digest*, September 1988.

149. Some growers claim that aeration systems would permit stocking densities of up to 40 pl per m^2 and achieve harvest increases of up to 50 percent. Such schemes are particularly appealing to growers with limited pond area. The economics of operating semi-intensive farms of less than 50 ha are questionable. While installing an aeration system would prove costly, about P/3 million per ha, it is much cheaper than P/10 million per ha to expand pond area. Other growers are skeptical, claiming that the more intensive system adversely affects pond bottoms. Some say that the economics is not yet proven at the farms which have installed aerators. Vesga, *op. cit.*, pp.67-68.

150. Maugle, *op. cit.*, p.6.

151. "Low Cost Shrimp Farming: An Answer to Falling Shrimp Prices," *Asian Shrimp News* 3rd Quarter 1990, p.4.

152. Cohen, *op. cit.*

153. Cohen reports that successful implementation of the APT polyculture system requires the use of high performance hybrid fish fry and adherence to a careful program of stocking and pond management. Cohen, *op. cit.*

154. See for example work conducted by INDERENA, Enrique Torres Q., "Levante Superintensivo de postlarvas *Macrobrachium rosenbergii* y engorde en policultivo con cachama blanca *Piaractus brachypomus* y mojarra plateada *Oreochromis niloticus,*" *in Memorias III Reunion Red Nacional de Acuicultura*, Cali, October 31 and Calma, November 1-3, 1989, pp. 201-217.

SECTION IX. (Yields/Production Costs)

155. One serious problem is that some authors do not carefully indicate whether their yield assessments are expressed in tail or whole weight or if it is per crop or year. Such inconsistencies can cause major discrepancies in reported data.

156. Maugle, *op. cit.*, p.4.

157. Revord and Weidner, "Ecuadorean Shrimp Culture," *op. cit.*

158. Persyn, "Tropical" *op. cit.*, p. 5.

159. Sanin, personal communications, September 11, 1990, *op. cit.*

160. Clifford, *op. cit.* As growers are averaging more than two crops per year, this would mean annual harvests exceeding 5.6 t per hectare.

161. Yield statistics, for example, affect the value of a grower's holdings and his ability to obtain financing at reasonable cost.

162. Persyh, *op. cit.*

163. ACUANAL reports that some Caribbean growers are harvesting about 2.5 t per ha per crop and as many as 3.2 harvests per year. Sanin, personal communications, *op. cit.*, June 7, 1991. Other observers are highly skeptical of such yields which would mean annual yields of nearly 8 t per hectare.

164. Persyh, *op. cit.* ACUANAL suggests somewhat higher yields, estimating that Pacific harvests are about 1.5 t per crop (and with about 2.5-2.8 harvests per year, annual yields would total 3.8-4.2 t per hectare. Sanin, personal communications, *op. cit.*, June 7, 1991. Other observers are skeptical about such high yields.

165. Growers were reporting feed cost increases of 35 percent annually. Vesga, *op. cit.*, p.74.

166. These estimates do not include financing costs. Vesga, *op. cit.*, p. 73.

167. Clifford, *op. cit.*

168. Maugle, *op. cit.*, pp. 5-6 and pp. 19-20. For details on Ecuador and Panama, 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.

169. Vesga, *op. cit.*, p. 73.

170. ACUANAL estimates that inexperienced growers operating a 150 ha farm could produce shrimp for about $5.10-$6.25 per kg along the Atlantic coast and $4.30-$5.30 per kg along the Pacific coast. For details see ACUANAL, "Analisis," *op. cit.* The authors were surprised to see lower production cost estimates for Pacific-coast growers. Most other observers suggest that costs are lower along the Caribbean coast.

SECTION X. (Feed)

171. Purina also produces a fish feed, primarily for the country's expanding tilapia culture industry.

172. Purina has subsidiaries producing shrimp feed in Brazil, Colombia, Guatemala, Mexico, Peru, and Venezuela.

173. The various rations are available in 5 percent increments. The higher increments contain other ingredients and improved qualities which Purina maintains meet all nutritional requirements and could thus be used as the sole feed in intensive operations. George Chamberlin, Aquaculture Director, Purina, personal communications, May 8, 1991.

174. Eduardo Abondano, Nutritionist, Alimentos Concentrados Raza, personal communications, May 29, 1991.

175. Alberto Meledez Sandoval, Gerente, Alimentos Concentrados Raza, personal communications, May 31, 1991.

176. Rodriguez Gomez, *op. cit.*

177. Vesga, *op. cit.*, p.69.

178. Danigo, *op. cit.* and Sanin, *op. cit.*, June 7, 1991.

179. Clifford, personal communications, July 12, 1991.

180. Betancourt, *op. cit.*

181. ACUANAL, "Analisis," *op. cit.*

182. Based on an average 1991 exchange rate of 630 pesos to the US dollar. ACUANAL, "Analisis," *op. cit.*

183. Long-time Colombian shrimp expert, Sergio Martinez, for example, believes that the feed problem is the industry's most serious difficulty. "Colombia: Production Up on Both Coasts," *The Fish Boat*, August, 1987, p.49.

184. Bernal de Mosquera, *op. cit.*

185. Vesga points out, however, that few Colombian growers have experience with imported feed. Vesga, *op. cit.*, p.68.

186. Maugle concluded that slow growth and low survival rates may be at least partially due to the lack of high quality feeds. His report also includes suggestions for improving feeds. Maugle, *op. cit.*, pp.16-17.

187. Vesga, *op. cit.*, p.69.

188. ACUANAL points out that shrimp culture is a relatively new industry in Colombia and that it was not feasible for feed companies to develop efficient feeds until growers began operations. ACUANAL reports that research is underway to improve feed formulas and that such improvement will proceed along with the industry's overall growth. Sanin, personal communications, *op. cit.*, June 7, 1991.

189. Chamberlin, *op. cit.*

190. Much of the Purina sales are 35 percent protein, compared to countries like Honduras where growers more commonly order 25 percent protein feed. Chamberlin, *op. cit.*

191. Melendez, *op. cit.*

192. Chamberlin, *op. cit.*

193. The most important factor in feed quality is protein content, but higher quality feed contains other ingredients to ensure that the complete dietary needs of the shrimp are satisfied. The higher protein content and various supplements all act to increase production costs.

194. This is understandable in most Latin American countries where shrimp culture is still a minor activity. Research has been limited, however, even in Ecuador, which is one of the leading world producers. Revord and Weidner, "Ecuadorean Shrimp Culture, " *op. cit.* See also Dennis Weidner, Tom Revord, and Randy Wells, "Latin American Shrimp Culture," *International Fishery Reports*, in press.

195. Clifford, *op. cit.*

196. Maugle, *op. cit.*, p. 26.

SECTION XI. (Postlarval Supply)

197. Even in the Latin American countries with available wild *P. vannamei* pl, the shrimp culture industry has only developed along the Pacific coast and not along the Atlantic/Caribbean coasts (Guatemala, Honduras, Mexico, and Panama) where the pl is not available.

198. Pl demand is difficult to estimate because of the variables concerned and the imprecise data available on Colombian growers. Appendices J1-3 provide a range of approximate pl demand. Based on available information pl demand probably amounted to about 0.3 billion pl in 1987 and increased to about 1.4 billion pl in 1990. Demand in 1991 may approach 2.0 billion pl (appendix I-4). Another observer estimates 1991 demand at 1.9 billion nauplii and 1.1 billion pl (appendix H2).

199. Jorge Pang, Technology and Sales Manager, Agromarina de Panama, personal communications, May 27, 1991.

200. A Pacific grower probably could collect enough pl for one or two ponds, but it would be a relatively laborious and therefore costly process. While a considerable amount of *P. stylirostris* is often available, it is usually mixed with large quantities of undesirable species, especially *P. occidentalis*. One grower reports trying to collect *P. stylirostris* pl for one farm, but it proved to be a very lengthy process requiring a considerable amount of labor and in the end they wound up with a large amount of *P. occidentalis*. Clifford, *op. cit.*

201. Maugle, *op. cit.*, p.15.

202. Despite the interest of Colombian growers in stocking some *P. stylirostris* together with *P. vannamei*, the fact that relatively little of the total production is comprised of *P. stylirostris* demonstrates how difficult it is in Colombia to obtain native, wild postlarvae. Clifford, *op. cit.*

203. Pang, *op. cit.*

204. Maugle, *op. cit.*, p.10.

205. Maugle, *op. cit.*, p.9.

206. Clifford, *op. cit.* The estimate is for pl imports only. Foreign sources are actually much more significant than suggested by this number. A very substantial portion of the domestic pl production is based on imported nauplii. If both pl imports and nauplii imports are combined, foreign suppliers accounted for about 70 percent of the seedstock supply. Clifford, *op. cit., June 12, 1990.*

207. Jorge L. Pang, "La Calidad y Rendimientos en la Produccion de Camaron *Penaeus vannamei* (Boone) Provenintes de Nauplios de Maduracion: El Caso de Agromarina de Panama," unpublished report, 1991. For general information on the Panamanian shrimp culture industry, see Weidner and Revord, "Panamanian Shrimp Culture," *op. cit.*

208. Pang, *op. cit.*

209. Pang, *op. cit.*

210. Robin Baily, PLC, personal communications, July 22, 1991, and Marc Harris, Director, PLC, personal communications, August 18, 1991. For more details on Panamanian hatcheries, see Weidner and Revord, "Panamanian Shrimp Culture," *op. cit.*

211. Vesga, *op. cit.* pp.52-53.

212. Acuerdo Ministerial No. 655, December 27, 1990.

213. Ecuador authorized the export of shrimp pl to Colombia and other countries. Imports are limited to pl produced through maturation, although the term does not appear to be strictly defined. The shipment of wild pl collected in the wild continues to be prohibited. "Patente de exportación de larvas de camarón," *El Universal*, January 16, 1991, and "Rechazan permiso para exportación de larvas," *El Universal*, January 5, 1991. See also Revord and Weidner, "Ecuadorean Shrimp Culture," *op. cit.*

214. INDERENA is interested in both pl production for shrimp culture and the repopulation of wild stocks. Luís E. Martínez Silva, Martha J. Torres V., Raul Remolina Caro, Martha Jeannette Torres V., and Jairo Maldonado Hincapie, "Reproduccion artificial de cinco especies diferentes de camaron marino para la obtencion de semilla como alternativa en el repoblamiento de areas naturales y desarrollo acuicola," INDERENA/CIP Cartagena, unpublished study, December 1984. While researchers have concentrated on *P. vannamei*, at least some work has been conducted on most important indigenous commercial species. Martínez, *et. al.*, "Propagacion ... P. subtilis," *op. cit.*; Martínez, *et. al.*, "Propagacion ... *P. schmitti*," *op. cit.*; Ting-Lang Huang, Jia-Jinn Chiu, Mao Tsung Huang, Liu Chin-Yang, Raul Remolina, Martha J. Torres V., Luís E. Martínez S., and Rodrigo Valencia, "Prppagacion artificial y desarrollo larval del camaron comercial *Penaeus* (M) *brasiliensis* Latreille del Caribe Colombiano," INDERENA/CIP Cartagena, unpublished study, 1979; and Martha J. Torres V., Luís E. Martínez S., Raul Remolina Caro, and Jairo Maldonado H., "Propagacion artificial y desarrollo larval del camaron titi *Xiphopenaeus kroyeri* Heller (1862) en el laboratorio," INDERENA/CIP Cartagena, unpublished study, 1982.

215. Raul Remolina Caro, Jairo Maldonado H., Luís E. Martínez S., and Martha J. Torres V., "Produccion masiva de postlarvas del camaron gigante malasiano *Macrobrachium rosenbergii* (De Man) y la influencia de la densidad poblacion en la supervivencia de los estados larvales," INDERENA/CIP Cartagena, unpublished study, 1982; Pan, *et.al.* "Tecnica," *op. cit.*; Ting, "Obtencion," *op. cit.*; Ting, "Descripcion," *op. cit.*; and Henry Von Prahl and Fernando Sanchez, Unidad de biofiltracion para el desarrollo larval de *Macrobrachium rosenbergii*," *Red Acuicultura Boletin*, Vol. III: 2, May/August 1989, pp. 13-15.

216. One report estimates the investment required at anywhere from $0.05 million to $1.20 million. Vesga, *op. cit.*, p.50.

217. Maugle, *op. cit., p.10.*

218. One observer provides a higher production estimate. He calculates that 12 hatcheries produced about 80 million pl/month in 1990, which would total nearly 1.0 billion per year. Philippe Danigo, France Aquaculture, personal communications, March 12, 1991.

219. Edgar Arias Avila, Manager, Hidrocultivos de la Costa, personal communications, January 10, 1992.

220. PROEXPO Washington Office, *op. cit.* Some observers suggest that a larger number of hatcheries are attempting maturation.

221. One observer reports that only one is reporting real success. Danigo, *op. cit.* Another observer maintains that both are reporting successful results. Clifford, *op. cit.*, July 12, 1991.

222. Philippe Danigo, France-Aquaculture, item 15.11.27, *Aquaculture Digest*, November 1990 and Sanin, personal communications, *op. cit., September 11, 1990.*

223. Roy Buddle, Regional Director, SANOFI Aquaculture, personal communications, August 12, 1991.

224. Mario Calderon Bozzi, Manager, Camarones Triple K, personal communications, December 12, 1991.

225. Clifford, *op. cit.*, July 12, 1991.

226. Rafael A. Ramirez Rodriguez, Gerente, INMARES Ltda., personal communication, December 9, 1991.

227. Ramirez, *op. cit.*

228. Arias, *op. cit.*

229. Ramirez, *op. cit.*

230. Ruben A. Maiguel, General Manager, Inversiones Camaroneras, personal communication, July 24, 1991.

231. Ramirez, *op. cit.* and updated February 4, 1992.

232. Guillermo Jaramillo, Manager, PROLARVAS, personal communications, December 2, 1991.

233. William Paternina Gonzalez, Production Chief, Post-Larvas (Rancho Chico), personal communications, December 10, 1991.

234. One 1989 report cited three hatcheries, but did not identify them. One of the hatcheries produced pl, the other two supplied nauplii to Caribbean growers and hatcheries. Martha Jeannette Torres, INDERENA, "Shrimp Farming in Colombia," *Artemia Newsletter*, April 1989, p.5.

235. Persyh, *op. cit.*

236. Hernando Victoria Bueno, General Manager, IDELPACIFICO, personal communications, December 23, 1991.

237. Betancourt, *op. cit.* and Bueno, *op. cit.*

238. Some observers anticipated production of up to 250 million postlarvae. Sanin, personal communications, *op. cit.*, June 7, 1991.

239. Bueno, *op. cit.*

240. The authors have confirmed reports that IDELPACIFICO is purchasing nauplii from NAPASA. Betencourt, *op. cit.* The authors do not, however, have confirmation on closed-cycle operations or the level of production.

241. Maugle, *op. cit. May 22, 1991.*

242. Most growers report better survival rates and yields from wild pl. Revord and Weidner, "Ecuadorean Shrimp Culture," *op. cit.*

243. Specific details on Colombian hatcheries are not available, but probably are similar to the increasing care being taken by Ecuadorean hatcheries. Not only are the hatcheries weeding out bad batches, but many Ecuadorean farms send technicians to the hatcheries to evaluate pl before they are shipped to the farms. Rosenberry, *op. cit.*

244. Rosenberry, *op. cit.*

245. Pond management is a critical factor. Clearly Colombian yields are not just a reflection of the excellent Colombian growing conditions, otherwise Colombian growers would have reported high yields throughout the 1980s and not just since 1987. Even today not all farms are reporting the impressive results achieved at Colombia's better farms. Clifford, *op. cit.*, June 11 and July 12, 1991.

246. Bernal de Mosquera, *op. cit.*

247. Maugle, *op. cit., p.11.*

248. Presumably pl produced from imported nauplii obtained from wild berried females will yield better results than full cycle maturation postlarvae.

249. Such operations would be limited to the Pacific coast as *P. vannamei* does not occur in the Caribbean.

250. Theoretically a program exists (Plan Vallejo) to obtain duty exemptions for equipment used in export production. The process, however, is complicated and does not address the problem hatchery operators face when an item is needed immediately.

251. See: "XVI. Government Role."

252. Another observer estimated that in 1989 pl demand was over 0.8 billion postlarvae. Maugle made his assessment by multiplying pond area (3,000 ha) by the stocking density (10m2) by an average of 2.5 harvests per year. The resulting number (0.8 billion pl) has to be increased to account for losses during transport to the ponds. Maugle, *op. cit.*, p.12.

253. Vesga, *op. cit.*, pp.51-52.

254. Maugle projects 1990 pl demand at about 2.0 billion postlarvae. Maugle, *op. cit*, p.26. Another observer estimates 1991 demand at 1.9 million nauplii and 1.1 million postlarvae (appendix H2).

255. One observer doubts if even 50 million pl were collected during 1990.

256. The information is based on information obtained in April 1991. Pang, *op. cit.*

257. ACUANAL, "Analisis," *op. cit.*

SECTION XII (Harvests)

258. "Colombia Trebles Shrimp Harvest," *Fish Farming International*, October 1991.

259. Sanin, personal communications, *op. cit.*

260. PROEXPO, *op. cit.*

261. Maugle, *op. cit., p.1.*

262. Vesga, *op. cit.*, p. iii.

263. "Colombia Will Have Shrimp Project," *Aquaculture Magazine*, March-April 1983.

264. The Santo Domingo group reportedly assessed the potential for *Macrobrachium* culture along the Caribbean coast. Details on the results, however, are unavailable. "Colombia: A Drive for Rapid Development of Fisheries," *Fish Boat*, August 1982, p.79.

265. "Granjas camaroneras en zonas fronterizas," *El Espectador,* September 9, 1984.

266. This was a major development. Most of the major Colombian shrimp farms are currently associated with important Colombian economic groups. Vesga, *op. cit.*, pp. 42-43.

267. Graciela Large, "Cultivo de camaron: US$3.8 millones alcanzó la inversion," *El Universal* September 14, 1986.

268. U.S. Embassy, Bogota, May 19, 1987.

269. Pl averaged about $12 per 1,000 postlarvae.

270. Vesga, *op. cit.*, p.40.

271. Several observers stress the importance of foreign consulting firms in addressing the industry's serious technical problems. Vesga, *op. cit.*, p. iii. TMT in particular played a critical role at several different farms.

272. Sanin, "La Acuicultura," *op. cit.*

273. Vesga, *op. cit.*, pp.51-52.

274. Vesga, *op. cit.*, p. 108.

275. A 30,000 t harvest could be expected from yields of 5 t per ha on 6,000 ha of ponds. Such a goal assumes the construction of about 400 ha of ponds per year and gradual improvements in pond management.

276. A 100,000 t harvest could be achieved from 40,000 ha of ponds yielding 2.5 t per ha or from 30,000 ha of ponds yielding 3.3 t per hectare. Such an expansion would require a major effort by growers, but is well within the range of possibilities given current trends.

277. Mora, personal communications, April 4, 1991, *op. cit.* One of the hatcheries is operated by Colombiana de Acuacultura. Alvaro Gonzalez, Gerente, Colombiana de Acuacultura, personal communications, March 30, 1988.

278. PROEXPO, *op. cit.*

279. FAO, "Aquaculture Production, (1986-89)" *FAO Circular*, No. 815, revision 3 (provisional), FIDI/C815, Rev. 2, April 1991.

280. INFOPESCA, *Noticias Comerciales*, September 1, 1988.

SECTION XIII (Harvest Procedures)

281. Sol Barreto, Erin Sales, personal communications, May 8, 1991.

282. ACUANAL, "Colombian Shrimp," advertising leaflet, 1990.

283. ACUANAL, "Analisis," *op. cit.*

284. Clifford, *op. cit.*, July 12, 1991. Counts are expressed on a tail weight basis.

285. The authors have not been able to confirm the very substantial difference (Pacific: 17 grams and Caribbean 11 grams) by other sources.

SECTION XIV (Processing)

286. Maugle, *op. cit.*

287. Larson, *op. cit.*

288. Richard Galofre Carrasco, Jefe de Departamento de Biologia, Vikingos de Colombia, personal communications, August 8, 1991. The shipments to Japan are believed to be primarily the trawler-caught pink shrimp. (See "Markets.")

289. Diana Gomez Kopp, Manager, Cartagena Shrimp Company, item 13.1.26, *Aquaculture Digest*, January 1988.

290. ACUANAL, "Analisis," *op. cit.*

291. Barreto, *op. cit.*

292. The authors have a report that **Maragricola** opened a new packing plant in early 1991, but this may refer to the IDELPACIFICO plant as Maragricola is associated with IDELPACIFICO..

293. ACUANAL, "Analisis," *op. cit.*

294. Vesga, *op. cit.*, pp. 88-89.

295. See for example, Robert Lambert, "Value Added Shrimp Products in Europe," *INFOFISH International*, 4/1990.

296. Vesga, *op. cit.*, pp. 93-95.

297. Barreto, op. cit.

298. Some product, however, has been imported illegally. Four people in New York became ill as a result of eating illegally imported Ecuadorean crab. Christine Gorman, "Death in the Time of Cholera," *Time,* May 6, 1991, pp. 58-61.

299. Several Latin American countries restricted Peruvian seafood imports after the cholera outbreak. While the U.S. FDA had not restricted the importation of Peruvian seafood products as of March 1991, FDA did issue an import alert, under which the it collects samples of Peruvian seafood at the U.S. port of entry. The current import alert also directs the 100 percent sampling of all Colombian and Ecuadorean crustaceans for cholera.

300. Ron Rogness, National Fisheries Institute, personal communications, May 24, 1991.

301. Various industry sources have assured the authors that their product is "cholera free." Betancourt, *op. cit.*

SECTION XV. (Markets)

302. ACUANAL, "Analisis," *op. cit.*

303. U.S. Embassy, Bogota, May 14, 1991. One of the other important non-traditional industries is flowers. Colombia has become the second largest flower exporter in the world. Elias, *op. cit.*

304. Available trade data is somewhat confusing. ACUANAL reports that Colombian shrimp exports totaled \$30 million in 1991. U.S. imports, alone, however, exceeded \$30 million. If the value of Japanese and EC imports are computed, total imports from Colombia exceeded \$50 million in 1990. The reason for this

discrepancy is unknown, but may relate to the tendency of Latin American growers to undervalue shipments in an effort to circumvent regulations controlling foreign exchange dealings, profit repatriation, and taxes. Partially for this reason, the authors have focused primarily on quantitative data in assessing export shipments.

305. A good recent assessment of world market trends is available in Charles Peckham, "Shrimp--Bargain Buys Coming to an End," *Seafood International*, October 1991, pp. 21-29.

306. Vesga, *op. cit.*, p.82.

307. *Fish Farming International*, November 1989.

308. Galofre, *op. cit.*

309. Some information on current European market trends is available in Peckham, *op. cit.*, 28-29.

310. Galofre, *op. cit.*

311. Vesga, *op. cit.*, p.28. 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 p.

312. Sanin, personal communications, *op. cit.*, March 19, 1991.

313. Sanin, personal communications, *op. cit., September 11, 1990.*

314. PROEXPO, *op. cit.*

315. Dan Spotts, President, Aqua-culture, personal communications, May 22, 1991.

316. Vesga, *op. cit.*, p.28.

317. "Colombia: Vikingos is a Name to Reckon With," *Fish Boat*, August 1983, p.76.

318. Galofre, *op. cit.*

319. Vesga, *op. cit.*, p.84.

320. Tom Asakawa, Fisheries Trade Specialist, U.S. Embassy Tokyo, personal communications, July 30, 1991.

321. Presumably the freshness of the product is more important than preferences for trawler-caught shrimp, although price may be another factor. Asakawa, *op. cit.*

322. The FEDESARROLLO study has not yet been published. Sanin, "La Acuicultura," *op. cit.*

SECTION XVI. (Government Role)

323. Ley 13 (1990).

324. Vesga, *op. cit.*, pp. 101-103.

325. Sanin, "La Acuicultura," *op. cit.*

326. For details on the PROEXPO promotional program see Guillermo Ibarra, "Acciones de PROEXPO en acuicultura," in *Memorias II Reunion Red Nacional de Acuicultura*, Neiva, September 1988, pp. 301-303.

327. Albeiro Velez Gomez, Director of Fish Technology, *Universidad del Choco*, personal communications, February 1991. ACUANAL concurs that the PROEXPO assistance with credit, market development, and technology was of great assistance. ACUANAL, "Analisis," *op. cit.* For details on loan terms, see Ibarra, *op. cit.*, pp. 302-303.

328. U.S. Embassy, May 25, 1984.

329. PROEXPO, *op. cit.*

330. "Colombia: Production Up on Both Coasts," *Fish Boat* August 1987 and Colombia Trebels Shrimp Harvest, *Fish Farming International*, October 1991. The Government also permitted the use of limbo funds for shrimp culture investment. Limbo funds are foreign capital which for technical reasons were not properly registered and hence cannot be remitted abroad under Colombian exchange control regulations. U.S. Embassy, Bogota, May 25, 1984.

331. World Bank officials report that they no longer administer projects with a shrimp culture component. Mirtha Araujo, Agriculture Division, World Bank, personal communication, May 22, 1991. The International Finance Corporation (IFC), the World Bank commercial subsidiary, also reports that they have no shrimp culture loans in Colombia. Carmen Torres, Colombia Desk, IFC, personal communications, May 22, 1991.

332. The aquaculture industry in many Latin American countries is a relatively new industry and many countries are just beginning to develop their regulatory framework. A good review of the various potential government concerns and alternative regulatory schemes has been prepared by FAO. 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, Rome, 1989, 81p.

333. Decree No. 533 (1986).

334. Decree No. 2324 (1984).

335. DIMAR's authority is granted under Decree No. 2349 (1971) and 2324 (1984).

336. Houtte, *et. al.*, op. cit., p. 42.

337. National Code of Renewable Natural Resources and Environment Protection (1974), Article 9 and 49.

338. Decree No. 1594 (1984).

339. "Colombia & Ecuador - Shrimp Farming's 'Huge Expansion'," *World Fishing* September 1985.

340. One observer reports that about 50 different government agencies have responsibility for some phase of the approval, construction, or operation of a shrimp farm. Potential growers found attempting to deal with so many often conflicting authorities was proving to be a legal nightmare. Vesga, *op. cit.*, p. 100. Not only were many agencies requiring duplicative procedures, but some agencies had conflicting requirements.

341. The program was begun under President Barco and has been vigorously continued by President Cesar Gaviria. A good description of the program and the current Colombian economic policy has been prepared by the U.S. Embassy, Bogota, May 14, 1991.

342. The actual amounts were 4.6 billion pesos and 0.8 billion pesos, respectively. PROEXPO Washington Office, *op. cit.*, May 20, 1991. The 1990 exchange rate varied from 434-688 pesos to the dollar and stood at 502 pesos at the end of June 1990. Banco de la República, December 1990. An approximate exchange rate of 500

was used in computing the U.S. dollar figures.

343. Velez, *op. cit.* PROEXPO itself is being reorganized. The future role of the agency will be an export-import bank and the agency is being renamed the Banco de Comercio Exterior. Law 07 (1991). PROEXPO officials maintain that the agency has in part been performing the duties of an export-import bank, but with a somewhat different approach. PROEXPO Washington Office, *op. cit.*, May 20, 1991. Many exporters believe, however, that the Government intends to terminate credit subsidies and to reduce the agency's export promotion activities. U.S. Embassy, Bogota, May 14, 1991. PROEXPO officials respond that Law 07 makes it clear that the bank will conduct a wide range of export promotion activities which will not be limited to credit services. Article 21 of the law reads "The Bank for Foreign Trade is hereby created as a financial institution under the authority of the Ministry of Foreign Trade, in charge of implementing export promotion activities. Promotion activities will be carried out, among others, through the commercial offices abroad. The offices will be attached to the embassies of Colombia." This commitment has been affirmed by several Government officials, including Carlos Caballero, PROEXPO Director General. PROEXPO Washington Office, *op. cit.*, May 20, 1991.

344. The Government is reducing the CERT to end the subsidy portion, leaving only a smaller reimbursement for indirect taxes.

345. Sanin, "La Acuicultura," *op. cit.*

346. For details see Vesga, *op. cit.*, pp. 112-114.

347. Velez, *op. cit.*

348. Hermes Figueroa, "A camaricultores, se los lleva la corriente," *El Universal*, June 10, 1992.

349. PROEXPO, *op. cit., May 20, 1991.*

350. "The Government acknowledges that those changes pursued by the modernization program are profound and that they will not be accomplished overnight. Therefore, its implementation has been designed on the basis of clear-cut rules. The Government also acknowledges that it will be difficult, if not impossible, for all firms and economic sectors to benefit from this new development model, and that the best results will be experienced by those which adequately assimilate such a change and undertake the necessary adjustments in a timely manner. However, it is also clear that those which export now or in the future can count on the necessary support to carry out fully the activities associated with their successful strategy." Carlos Caballero Argáez, PROEXPO Director General, presentation before the VIII National Assembly of Exporters, Bogotá, November 1-2, 1990.

SECTION XVII. (Credit)

351. Vesga provides a detailed assessment of the credit situation in Colombia. Vesga, *op. cit.*, p.75-80.

352. See footnote 314.

353. ACUANAL also mentions shortages of trained personnel, limited technical capability, higher than expected investments for additional hatcheries, infrastructure, packing plants, shipping and equipment needs. ACUANAL, "Analisis," *op. cit.* These factors are discussed in more detail in "Outlook" of this report.

354. Vesga, *op. cit.*, pp. 79-80.

355. ACUANAL, "Analsis," *op. cit.*

SECTION XVIII. (Technical Capability)

356. Available addresses of known research institutes are listed in appendix A.

357. Many of the important researchers are listed in the "Sources" section of this report.

358. Colombian growers have initiated operations without the advantage of locally available postlarval seedstock. Not only have they developed the region's second largest industry, but they are intensifying growout operations. The combination of these factors (relying on hatcheries, expanding pond construction and harvests, and intensifying methods) suggests growers will increasingly face very significant technical questions.

359. Several Colombian researchers have prepared numerous assessments of possible aquaculture research and training policies. See *RED Tercera Sesion, "Estrategias para el Desarrollo de la Acuicultura en la Decada del 90," Memorias III Reunion Red Nacional de Acuicultura*, Cali, October 31 and Calma, November 1-3, 1989, pp. 307-462. The RNA will hold its IV annual meeting in Bogotá, August 28-30, 1992. The theme of the meeting will be "Aquaculture Scientific and Technical Development".

360. Jorge Eduardo Forero U., Profesor, Biology Department, Universidad Nacional de Colombia, personal communications, July 19, 1991.

361. The researcher points out that much of this work has not been circulated within the Colombian research establishment, much less the international community. Forero, *op. cit.*

362. The authors are much obliged to Dr. Forero at the Universidad Nacional de Bogota for providing resumes of several recent Colombian academic works that would otherwise have been unavailable for this study.

363. Vesga, *op. cit.*, p. 116.

364. Given the level of investments Colombian growers are making in the shrimp culture industry, this attitude may seem surprising to U.S. readers. Colombia as in other Latin American countries has not had highly successful research programs that have benefitted farmers and fishermen like the Land Grant and Sea Grant programs. Even in the United States, however, it is not unusual for practical farmers and fishermen to criticize "ivory tower" academic thinking.

365. Vesga, *op. cit.*, p. 63.

366. Maugle, *op. cit.*, p.13.

367. The problem is especially severe in Panama. See Weidner and Revord, "Panamanian Shrimp Culture," *op. cit.*

368. Vesga, *op. cit.*, pp. 65-67.

369. A good review of the country's aquaculture industry is available in A. Hernandez, R. Puentes, P Moya, and J. Plata, *Estudio socioeconomico de la acuicultura en seis regiones de Colombia*, COLCIENCIAS/CIID, 1989.

370. Dr. Grajales confirms that the University of Caldas research efforts have been limited to finfish. Alberto Grajales Quintero, Director, Centro de Invesigación Piscícola, personal communications, June 11, 1991.

371. Fernando Acosta Conti, Facultad Biologia Marina, Universidad de Bogota, personal communications, May 27, 1991.

372. Ramos, *op. cit.*, p.237.

373. A good description of INDERENA's facilities and programs (both marine and freshwater) is available in Horacio Rodriguez, "Experiencias del INDERENA en el desarrollo de la acuicultura rural," in *Memorias II Reunion Red Nacional de Acuicultura*, Neiva, September 1988, pp. 63-76.

374. See for example Martinez, Pedini, and New, *op. cit.*

375. See, for example, Pan Jia Mo, Lu Zhi Guo, Yu Zi Hao, Luis E. Martinez Silva, David Osorio Dualiby, and Martha J. Torres Virviescas, "Cultivo Intensivo del Camaron de Agua Dulce *Macrobrachium rosenbergii* (de Man)," *Trianea* (Act. Cient. Tecn. INDERENA Vol. I, 1988, pp. 45-55. Colombia and China signed a technical cooperation agreement in 1976. The initial Taiwan technical team consisted of two fish culture and two shrimp culture experts. "Fishery Pact with Colombia," *China Post*, April 21, 1976.

376. Romero and Von Prahl, *op. cit.*

377. Germán A. Bolívar, Jefe Sección de Biologia Marina, Universidad del Valle, personal communications, January 22, 1991.

378. Von Prahl and Ríos, *op. cit.*

379. Avila and Von Prahl, *op. cit., pp. 239-251.*

380. A good description of INVEMAR's program and facilities is available in Maria Mercedes Criales, "Proyecto de maricultura en INVEMAR," in *Memorias II Reunion Red Nacional de Acuicultura*, Neiva, September 1988, pp. 211-216.

381. Newmark, *op. cit.*

382. Juan Ricardo Morales E., Jefe, Division Sector Marino, COLCIENCIAS, personal communication, September 3, 1991.

383. See for example Grupo Acuicultura Marina, "Experiencia de transplante de camarones marinos de Tumaco a Cartagena," INDERENA/CIP Cartagena, 1983, 18 p. and Torres and Martinez, *op. cit.*

384. Luis E. Martínez Silva, Pilar Dorado Longas, and Martha J. Torres Virviescas, "Cultivo experimental de camaron marino *Penaeus vannamei* Boone, en agua dulce," in *Memorias III Reunion Red Nacional de Acuicultura*, Cali, October 31 and Calma, November 1-3, 1989, pp. 253-267.

385. Morales, *op. cit.*

386. Morales, *op. cit.*

387. Newmark, *op. cit.*

388. LeCompte, *op. cit.*

389. Liga Urbina de Gomez, "Programa Nacional de Pesca y Acuicultura en la SENA," in *Memorias II Reunion Red Nacional de Acuicultura*, Neiva, September 1988, pp. 305-309.

390. Ricardo Alvarez-Leon, personal communications, June 19, 1991.

391. Forero, *op. cit.*

392. Vesga says that some growers have complained of the training offered. One grower said "The best would be for the university not to teach them anything about shrimp. That would reduce what we have to teach them." Vesga, *op. cit.*, p.72.

393. Vesga, *op. cit.*, p.73.

394. Bernal de Mosquera, *op. cit.*

395. Maugle, *op. cit.*, pp.6-7.

396. Vesga, *op. cit.*, p.72.

397. Maugle, *op. cit.*, pp.13 and 22.

398. Vesga, *op. cit., p. 58-59.*

399. A synopsis of industry views over the role of foreign consultants can be found in Vesga, *op. cit.*, pp. 57-64.

400. Ramirez, *op. cit.*

401. Rodriguez Gomes, *op. cit.*

402. "Operational Summary," *The Courier*, no. 128, July-August 1991, xiii.

403. "Minor Field Study," *op. cit.*, p. 2.

404. "Colombia," *Fishing Gazette*, July 1980.

405. See research studies listed under Pan and Ting.

406. ACUANAL reportedly is helping to coordinate the project. Vesga, *op. cit.*, p.106. For some preliminary results see Lemaitre, *op. cit.*

SECTION XIX. (Disease)

407. Several Asian countries pursuing high-density methods have reported disease problems, especially the disastrous experience in Taiwan during 1988. Many Taiwan growers have diversified the species cultured, to reduce the possibility of future disease outbreaks. For details on the Taiwan situation, see Todd Schneider and Mark Wildman, "Taiwan Shrimp Culture," *International Fishery Reports*, (IFR-91/61), August 16, 1991. Some Taiwan growers would now reportedly like to resume culture of black tiger shrimp, *P. monodon*. "Recommendations for Improving the Health of Cultured Shrimp in Taiwan," *Asian Shrimp News, 1st Quarter 1990, p.1.* Other reports suggest that other countries are encountering serious disease problems. Thailand has greatly expanded cultured harvests and reports from that country suggest that growers are reporting major problems, especially in the more established areas. See Paul Niemeier, "Thailand's Shrimp Aquaculture," *International Fishery Reports*, (IFR-89/95), November 28, 1989, and Mark Wildman, "Thailand's Shrimp Culture, 1990," *International Fishery Reports*, (IFR-91/20),

408. Some U.S. experts are convinced that shrimp diseases have had a "devastating" impact on shrimp farmers in the United States and foreign countries. The Oceanic Institute in Hawaii held a workshop in July 1991 to review plans for specific pathogen-free (SPF) shrimp for the U.S. Marine Shrimp Farming Program. The Oceanic Institute, *Newsline*, September 1991, p. 1.

409. FUB reports, for example, thesis work on "Flora bacteriana en la cria con y sin biofiltacion de camaron *Penaeus* vannamei ," (1991), "Tratamiento quimico con Bactrín (Trimetropin-sulfa) de *Vibro algonilithycus* en padrotes de camar6n *Penaeus vannamei*," (1990), and "Patologia y tratamientos aplicados a larvas y post-larvas cultivados en laboratorio, de los camarones *Penaeus schmitti* y *P. vannamei*," (1990). Pedro Le Compte, Faculty of Marine Biology, Fundacion Universidad de Bogota, personal communications, June 18, 1991.

410. Newmark, *op. cit.*

411. See, for example, Luís, Martínez Silva, A.M. Molinares, J. Villanueva, and D.A. Conroy, "Preliminary Observaciones on the Application of Nifurpirinol for the Control of Potential Disease Problems in *Macrobrachium acanthurus*," INDERENA/CIP Cartagena, unpublished study, 1980.

412. Bernal de Mosquera, *op. cit.*

SECTION XX. (Social Impact)

413. Betancourt, *op. cit.*

414. Vesga, *op. cit.*, p.71.

415. Employment estimates vary somewhat. One source suggests about 3,700 workers. U.S. Embassy, Bogota, May 14, 1991.

416. Corner Bailey and Mike Skladany, "The Political Economy of Aquaculture Development in the Third World," *ICA Communicae*, December 1989, Vol. 12, No.1-2, pp. 6-8.

417. This is of course primarily because of the much more limited pond construction in Colombia. It is also partly due to the existence of much less mangrove forestry along Colombia's Caribbean coast.

418. The author assesses the role of outside capital (both Colombian and foreign) in producing export commodities rather than products for local consumption. Plata, *op. cit.* Plata's argument is primarily ideological and he provides no hard data concerning the relative impact of the shrimp culture industry on local communities.

419. One of the most important coastal zones studies in Latin America has been undertaken by the University of Rhode Island's Coastal Resources Center. The study is assessing costal zone management in Ecuador as part of the country's Coastal Resources Management Program. A published assessment of the major findings, however, is not yet available.

420. Some of the impacts of aquaculture and inland fisheries development are discussed in I.G. Dunn, "Development of Inland Fisheries Under Constraints from Other Uses of Land and Water Resources: Guidelines for Planners," *FAO Fisheries Circular*, No. 826 (FIRI/C826), November, 1989, 53 p.

SECTION XXI. (Outlook)

421. The rapidly rising cultured harvests from Asian countries may have a major impact on the shrimp market. Further declines in the real price of shrimp could have major consequences on Latin American producers.

422. This estimate is based on 1990 dollars. Expressed in inflated 2000 dollars, Colombian cultured shrimp export earnings would more likely approach $0.3 billion.

423. Maugle, *op. cit.*

424. Clifford, *op. cit.*

APPENDICES

Appendix A.--Colombia. Directory of shrimp farms

Government Agencies

Dirección General Marítima y Portuaria (DIMAR)
Address unavailable
Bogota
COLOMBIA

Fondo de Promoción de Exportaciones (PROEXPO)
Calle 28, No. 13A-15
AA 240092
Bogota, Colombia
Telephone: (57) 2690777

Institute for Agrarian Reform (INCORA)
Ministerio de Agricultura
Address unavailable
Bogota
COLOMBIA

Instituto Nacional de Dessarrollo de Recursos Naturales y del Ambiente (INDERENA)
Jefe Division Acuicultura
Diagonal 34 No. 5-18, AA 13458
Bogota, COLOMBIA

Instituto Nacional de Recursos Naturales Renovables (INDERENA)
Subgerencia de Pesca y Fauna
Apartado Aereo 13458
Bogota, COLOMBIA

Research Groups

Centro de Investigaciones Marinas de Uraba (CIMUR)
Apt. Aereo 51928
Medellin
COLOMBIA

Centro de Investigaciones Pesqueras de Cartagena (CIP)
INDERENA
Apt. Aereo No. 2459/1820
Cartagena
COLOMBIA

Centro de Investigaciones Pesqueras (CIP)
INDERENA
Estacion Piscicola de Repelon
Apt. Aereo 983
Cartagena
COLOMBIA

Centro de Investigaciones Pesqueras de Tumaco (CIP)
INDERENA
Address unavailable
Tumaco
COLOMBIA

COLCIENCIAS
Tranvs. 9ª, No. 133-00
AA 651580
Bogota
COLOMBIA

Instituto de Inv. Marinas de Punta de Betin (INVEMAR)
Programa de Maricultura
Apt. Aereo 1016
Santa Marta, COLOMBIA

Instituto de Pisicultura Tropical
Apt. Aereo 124 Buga
Buga, Cauca
COLOMBIA

Museo del Mar
Universidad del Mar
Univeridad Jorge Tadeo Lozano
Bogota, COLOMBIA

Red Regional de Acuicultura
Apartado Aereo 251246
Bogota, D.E.
COLOMBIA

Universidad de Antioquia
Departamento de Biologia
Apt. Aereo 1226
Medellin
Colombia

Universidad de Cartagena
Investigaciones Marinas
Apt. Aereo 1382
Cartagena
COLOMBIA

Univeridad de Bogota
Facultad de Biologia Marina
Secional del Caribe
AA 1310
Carrtagena, COLOMBIA

Universidad Caldas
Centro de Investigacion Piscicola
AA 275
Manizales, COLOMBIA

Universidad del Choco
Tecnologia Pesquera
Quibdo, Choco
COLOMBIA

Universidad del Magdalena
Facultad Ing. Pesquera
Address unavailable
Santa Marta, COLOMBIA

Universidad del Valle
Seccion de Biologia Marina
Apt. Aereo 25360
Cali, COLOMBIA

Universidad Nacional de Colombia
Departamento de Biologia
Calle 65A, No. 80A 07 (Apt. Aereo 7495)
Bogota 9, D.C. COLOMBIA

Industry Group

Asociación Nacional de los Acuicultores de Colombia (ACUANAL)
Carrera 12A, No. 77A-66
AA 44010
Bogota, Colombia
Telephone: (57-1) 2177133; 2493737
FAX: (57-1)

Farms

Acuipesca
Edificio Seguros Bolívar
Local 1-100 Bocagrande
AA 20574
Cartagena, Colombia
Telephone: (57-53) 651313; 651340
FAX: (57-53) 653783

Agromarina Cispata
Calle 7ª, No. 30-47
AA 52965
Medellin, Colombia
Telephone: (57-4) 2557472
FAX: NA

Agromarina Tumaco
Calle 9A Norte, No. 8-65
AA 9045
Cali, Colombia
Telephone: (57-23) 681181; 681182
FAX: NA

Agromarina Santa Ana
Edificio Seguros Bolívar, Of. 13
AA 7045
Cartagena, Colombia
Telephone: (57-53) 654558; 653887

Agrosoledad
Playa de la Artilleria No. 33-36
AA 2
Cartagena, Colombia
Telephone: (57-53) 643573; 648166; 654702
FAX: (57-53) 655712

Agrotuo
Calle 10ª, No. 41-07, Of. 401
AA 66922
Medellin, Colombia
Telephone: (57-4) 2661532; 2661552
FAX: (57-4) 669565

Aquacultivos del Caribe
Edificio Seguros Bolívar, Of. 1454-A, Piso 1°
AA 4257
Cartagena, Colombia
Telephone: (57-53) 654352; 654353
FAX: NA

Aquacultura America
Tranversal 42B, No. 20-85, Piso 2°
Bogota, Colombia
Telephone: (57-1) 2690982; 2694868
FAX: NA

Aquamar
Carrera 2ª, No. 24-46
AA 4436
Cali, Colombia
Telephone: (57-23) 816979; 831183; 824030
FAX: (57-23) 835014

Camaronera Balboa
Calle 56, No. 47-14, Piso 3º
AA 3521
Medellin, Colombia
Telephone: (57-4) 2516700; 2517911
FAX: NA

Camarones del Caribe
Pedro de Heredia
Lo Amador Calle 11 No. 18C-207
AA 8397
Cartagena, Colombia
Telephone: (57-53) 665790
FAX: (57-53) 866780/885828; 665750

Cartagenera de Acuacultura
San Diego Cr. 7, No. 38-49
(Calle del Curato
AA 2
Cartagena, Colombia
Telephone: (57-53) 655069
FAX: (57-53) 655712

Cartagena Shrimp Company
Zona Franca de Mamonal Bodega 4
AA 2
Cartagena, Colombia
Telephone: (57-53) 685601; 685602
FAX: (57-53) 685692

C. I. Oceanos
Albornoz Carretera Mamonal
AA 4264
Cartagena, Colombia
Telephone: (57-53) 685285; 685505
FAX: (57-53) 685266

Colombiana de Acuacultura
Castillogrande, Calle 5, No. 10-71
Ed. Doroty, Piso 1
AA 20758
Cartagena, Colombia
Telephone: (57-53) 655353, 651774
FAX: (57-53) 655293

Compañia Caribeña
Calle 88, No. 18-44
AA 3521
Cartagena, Colombia
Telephone: (57-1) 2188952; 2189686; 2368610
FAX: (57-1) 571-6111026

Cultimar del Caribe
Centro Comercial Bocagrande L-209
AA 20054
Cartagena, Colombia
Telephone: (57-53) 653656, 653-696

Exportadora Cali
Carrera 2ª, No. 24-109
Cali, Colombia
Telephone: (57-23) 831919
FAX: (57-23) 835663

Guinulero
Calle 19 Norte, No. 2N-29
Torre de Cali, Piso 5º
Cali, Colombia
Telephone: (57-23) 610506
FAX: (57-23) 610410

Idelpacifico
Edificio Garces
Calle 11, No. 1-07, Local 2-11
AA 20132
Cali, Colombia
Telephone: (57-23) 835194; 835196
FAX: (57-23) 824627

Inversiones Camaroneras
Calle 92, No. 9-33
AA 51809
Bogotá, Colombia
Telephone: Bogotá: (57-1) 2571955; Cienaga: (9542) 41020
FAX: Bogotá: (57-1) 2187917

Maragricola
Avenida 8ª Norte, No. 21-55
AA 1873
Cali, Colombia
Telephone: (57-23) 676614; 676615-17
FAX: (57-23) 672927

Mariscal
Calle 65, No. 16-31
Bogota, Colombia
Telephone: (57-1) 2494468; 2494319; 2488914;2494419
FAX: NA

Perla del Pacífico
Address unavilable

Pexco
Edificio Belmonte Carrera 1ª, No. 24-56, Of. 412
AA 2010
Cali, Colombia
Telephone: (57-23) 832844;801904; 836843

Produmar
Calle 26 Norte, No. 5N-59
AA 31551
Cali, Colombia
Telephone: (57-23) 674378;674380
FAX: (57-23) 675334

(C. I.) Vikingos de Colombia
Albornoz Carrertera a Mamonal
AA 2858
Cartagena, Colombia
Telephone: (57-53) 685211; 685239; 685330
FAX: (57-53) 685162; 685106

Hatcheries

Acacias del Mar
Address not available

Acuacultivos del Caribe
Edificios Seguros Bolicar, No. 14-04
Apto 1
Cartagena, Colombia
Telephone: (953) 654352/3

Acuaribe
Carlos McLean U.
Calle 10, No. 38-35, Of. 204
Medellin, Colombia
Telephone: 3111-817/836

Camarones Triple K
Ave. Miramar de Manga, No. 20-187
Cartagena, Colombia
Telephone: (953) 662262
FAX: (953) 662262

CAMCAR
Ave. Pedro de Heredia
Sector Lomador No. 28-C-207
Cartagena, Colombia
Telephone: (953) 665790; 665750

CAPA
Calle Santo Domingo
Edificio Ferrer, Of. 301
Cartagena, Colombia
Telephone: (953) 654763; 643472

CARTACUA/TIGUA
Calle del Cuarto No. 38-49
Cali, Colombia
Telephone: (923) 655069, 647832,647830

Corporacion Autonoma Regional de los Valles del Sinu y del San Jose (CVS)
Calle 29, No. 2-43, 6ª piso
Edificio Morindo
AA 355
Monteria, Colombia
Telephone: (947) 824887; 822157

Hidrocultivos de la Costa
Carrera 2, No. 13-85, 2ª piso
Bocagrande
Cartagena, Colombia
Telephone: (953) 656929/31

IDELPACIFICO
Calle 11, No. 1-07
Edificio Garces
Local 2-11
Cali, Colombia
Telephone: (923) 835194; 835196; 819089

INDULARVA (Cienaga)
Address not available

Inversiones Camaroneras
Calle 92 No. 953
Bogota, Colombia
Telephone: (Bogota) 258-1955
Telephone: (Cienaga) (9562) 41-020

INMARES
Edificio de Conquistador
Apt. Aereo 20288
El Laguito, Local No. 16-01
Cartagena, Colombia
Telephone: (953) 650776; 650283
FAX: (953) 655878

Luis Fernando Martinez & Cia., SCS
AA 8026
Medellin, Colombia
Telephone: (94) 3111-198
FAX: (Tolu) (9528) 85296

Nauplius y Larvas del Pacifico
Calle 28 Norte, No. 4-N-70
Cali, Colombia
Telephone: (923) 673965

Nauplius y Larvas del Pacifico
Calle 10, No. 44-A-15
Local 17
Cartagena, Colombia
Telephone: (953) 355316
FAX: (953) 834489

PRODULARVA
Urbanizacion Camino Real No. 41
Ave. Camino Real Manga
Cartagena, Colombia
Telephone: (953) 660829

Rancho Chico
Pie de Popa
Cra. 19-A, No. 29-B-27
Cartagena, Colombia
Telephone: (953) 664714; 664712

Universidad del Valle
Ciudad Uiversitaria Melendez
Edificio Cree, 2ª piso
Carrera 29, No. 5-B-59
Apto. 302
Cali, Colombia
Telephone: (923) 566706; 302455

Feed Companies

Alimentos Concentrados Raza
Calle 8, No. 34-75
AA 10829
Bogota, Colombia
Telephone: (57-1) 2771251; 2478793; 2470104
Fax: (57) 2018120

Solla, S.A.
Km. 15 Via Occidente Mosquera
AA 80091
Bogota, Colombia
Telephone: 2672352; 2657990-94

Purina Colombiana
Carretera Occidente Km 18
AA 151047 El Dorado
Mosquera (near Bogota), Colombia
Telephone: (57-1) 8276169
FAX: (57-1) 8276170

Appendix B1.--Colombia. Capture shrimp fishery, 1975-90

Year	Caribbean	Pacific				Total**
	Penaeid	Penaeid	Seabob*	Other	Total	
		1,000 Metric tons				
1975	0.9	1.4	2.8	0.4	4.6	5.5
1976	0.1	1.1	3.3	0.7	5.1	5.2
1977	1.6	1.6	3.0	1.1	5.7	7.3
1978	0.3	1.7	3.2	0.5	5.4	5.7
1979	0.8	0.8	1.5	0.6	2.9	3.7
1980	0.5	1.3	2.3	0.5	4.1	4.7
1981	0.8	2.6	1.5	0.4	4.5	5.3
1982	1.8	2.1	2.1	0.1	4.3	6.0
1983	1.4	1.9	1.7	0.8	4.4	5.8
1984	2.7	1.9	2.0	1.5	5.4	8.0
1985	2.3	1.0	1.2	0.6	2.8	5.0
1986	2.6	1.3	2.0	0.4	3.7	6.2
1987	2.0	1.0	1.9	1.7	4.6	6.7
1988	2.4	1.0	1.5	0.5	3.0	5.3
1989	2.0	1.7	2.7	1.2	5.6	7.7
1990	NA	NA	NA	NA	NA	NA

NA - Not available
* Primarily seabob/titi (*Xiphopenaeus kroyeri riveti*) shrimp, but also includes another species of small shrimp, carabali/tigre (*Trachypenaeus byrdi*). This later species should not be confused with *Penaeus monodon*, commonly refereed to as black tiger shrimp in the United States.
** Totals may not agree due to rounding
Source: INDERENA

Appendix B2.--Colombia. Shrimp species

Species		
Scientific	English*	Spanish*
Marine		
Caribbean		
Penaeus	Penaeids	Penidios
brasiliensis	Red/pink spotted	Rosado con manchas/pintado
notialis	Southern pink	Rosado sureño/rojo
schmitti	Southern white	Blanco sureño
subtilis**	Southern brown	Café sureño
Xiphopenaeus kroyeri	Atlantic seabob	Siete barbas
Pacific		
Penaeus	Penaeids	Penidios
occidentalis	Western white	Blanco del Pacifico/langostino
stylirostris	Blue	Azul/blanco
vannamei	Whiteleg	Patiblanco/café
Trachypenaeus byrdi	Carabali	Carabalí/tigre
Xiphopenaeus riveti	Pacific seabob	Botalón/tití
Freshwater		
Macrobrachium	River prawn	Agua dulce
acanthurus	Cinnamon	Canela
amazonicum	Amazon	Amazónico
americanum	Cauque	Cauque
carcinus	Painted	Pintado
olfersii	Buchura	Buchura

* FAO terms, commonly used Colombian names after slash in Spanish column.
** Formerly considered to be a subspecies of *P. aztecus*. Previously this species was not distinguished from *P. brasiliensis*.
Source: FAO. "Shrimps and Prawns of the World" *FAO Species Catalogue*, Vol. I, Rome, 1980.

Appendix C1.--Colombia. Total shrimp production, wild-caught and cultured, 1980-92.

Year	Production Capture	Culture	Total	Portion Cultured
	1,000 Metric tons*			Percent
1980	4.7	-	4.7	-
1981	5.3	-	5.3	-
1982	6.0	-	6.0	-
1983	5.8	-	5.8	-
1984	8.0	Negl.	8.0	-
1985	5.0	0.1	5.1	1
1986	6.2	0.2	6.4	3
1987	6.7	0.5	7.2	7
1988	5.3	1.3	6.8	20
1989	7.7	3.0	10.7	28
1990	NA	6.0	NA	50E
1991	NA	9.8P#	NA	61E
1992	NA	10.5P	NA	63E

* liveweight
# Revised ACUANAL projection (June 7, 1991).
E - Estimates based on avaerage 1980-89 Colombian wild shrimp catches of 6,100 tons.
P - Projected
Source: ACUANAL data, provided by Armando Hernandez, Coordinator, Red Regional de Entidades y Centros de Acuicultura de América Latina, personal communications, January 1991 and Clara Maria Sanin Posada, President, ACUANAL, personal communications, March 19 and June 7, 1991 (cultured data); INDERENA (capture data).

Appendix C2.--Colombia. Freshwater shrimp harvest

Year	Harvest
	Metric tons
1986	1
1987	1
1988	3
1989	50

Source: FAO, "Aquaculture Production, (1986-89)" FAO Circular, No. 815, revision 3 (provisional), FIDI/C815, Rev. 2, April 1991.

Appendix D1.--Colombia. Shrimp farm pond area, 1985-92.

Year	Ponds: Constructed*	Ponds: Stocked	Utilization	Yield
	Hectares		Percent	Metric tons per Hectare♦
1985	438	300	68	0.4
1986	898	438	49	0.6
1987	1,819	1,310	72	0.4
1988	2,130	1,714	80	0.7
1989	3,016	2,022	67	1.5
1990	3,796	2,535	67	2.4
1991	4,080P	2,914P**	71P	3.4
1992	4,500P***	4,200P***	93P	NA

P - Projection
* Considerable caution should be used in assessing Colombian data on pond area. Much of the available data from Acuanal and other sources may include roads, canals, dikes, buildings, and undeveloped property. He believes that the 1991 pond projection of 4,000 ha may in fact amount to only 3,000 ha of actual water surface area. Clifford, op. cit.
♦ Harvest (as detailed in appendix C1) per ha of operating ponds.
** Another estimate suggests an area of 3,800 hectares.
*** Projected by ACUANAL in March 19, 1991. Current projections may have been scaled back.
Source: ACUANAL, provided by Martha Bernal de Mosquera, Subdirectora de Producción Pesquera, Ministerio de Agricultura, personal communications, April 4, 1991 and Clara Maria Sanin Posada, President, ACUANAL, personal communications, March 19 and June 7, 1991.

Appendix D2.--Colombia. Shrimp pond area expansion, 1985-91.

Year	Ponds: Constructed	Ponds: Increaase	Ponds: Stocked	Ponds: Increase
	Hectares	Percent	Hectares	Percent
1985	438	-	300	-
1986	898	105	438	46
1987	1,819	103	1,310	199
1988	2,130	17	1,714	31
1989	3,016	42	2,022	18
1990	3,796	26	2,535	25
1991	4,080P	7	2,913	15

P - Projection
Source: Clara Maria Sanin Posada, President, ACUANAL, personal communications, June 7, 1991.

Appendix D3.--Colombia. Cost structure at semi-intensive farms

Item	Operating costs
	Percent
Feed	20-30
Seedstock	20-24
Labor	10-15
Fuel	6-10
Other	44-21

Note: Cost estimates available on many other Latin American countries suggest higher feed costs.
Source: Rafael Vesga F., Casos de Exito de Desarrollo en Colombia: Las Exportaciones de la Camaricultura, FEDESARROLLO, November 1990, p.74.

Appendix E.--Latin America. Sea surface tempertures, 1989-91

Year/ Month	Pacific			Atlantic	
	Northern Peru	Southern Ecuador	Colombia*	Colombia	Northeast Brazil
			Degrees Celcius		
1989					
January	21	23	26	27	27
February	23	24	24	26	27
March	23	25	25-26	27	28
April	23	25	27	27	26
May	19	21	26-27	28	27-28
June	20	24	26-27	27-28	27
July	20	22	26-27	28	27-28
August	19	23	26-28	29	26-27
September	18	22	26-28	29	27
October	19	23	26-28	29	27
November	19	22	26-27	28	27-28
December	21	25	26-27	28	27
1990					
January	22	25	26-27	27	27
February	22	25	26	26-27	27
March	23	26	27-29	26-27	27
April	21	24	26-27	26-27	27
May	22	25	27-28	28-29	28
June	21	24	27-28	28-29	27
July	20	24	26-28	28-29	27
August	20	25	25-28	28	25-27
September	21	25	25-28	29	25-27
October	19	22	25-27	28	26-27
November	20	22	25-28	28	26-27
December	21	22	26-27	27	27
1991					
January	23	24	26-27	27-28	27
February	25	26	26	26-27	27
March	24	25	27	27	27-28
April	23	24-25	27-28	27-28	28-29
May	22	24	27-28	27	28
June	21	25	27-28	27-29	27-28
July	20	24	27-28	27-28	26-27
August	20	24	27-28	27-28	26-27
September	19	23	26-27	28	25-26
October	20	25	26-28	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 F.--Colombia. Shrimp culture statistics, by coast

Year/Coast	Ponds		Harvest	Exports
	Constructed	Stocked		
	Hectares		Metric tons	US$ Million
1989				
Caribbean	1,631	1,080	1,992	11.2
Pacific	1,385	942	981	4.8
Total	3,016	2,022	2,973	16.0
1990				
Caribbean	2,044	1,504	4,314	22.4
Pacific	1,752	1,031	1,695	8.4
Total	3,796	2,535	6,009	30.8
1991				
Caribbean	2,166P	1,631P	6,452P	34.5P
Pacific	1,914P	1,282P	3,380P	15.6P
Total	4,080P	2,913P	9,832P	50.1P

P - Projected
Note: Discrepancies with appendix C are unexplained, but apply primarily to projected data which by definition is imprecise.
Source: Clara Maria Sanin Posada, President, ACUANAL, personal communications, March 19, 1991.

Appendix G1.--Colombia. Principal shrimp farms, 1990

Coast/Farm	Pond area
	Hectares
Caribbean	
Cartagenera de Acuacultura	400
Agrosoledad	180
Colombiana de Acuacultura	180
Acuipesca	174
Camarones del Caribe	179
Aquacultivos de Caribe	120
Pacific	
Aquamar	170
Maragricola	240
Camaronera Balboa	115
Caribena	100

Source: Harvey Persyh, Tropical Mariculture, personal communications, October 1990 and Henry C. Clifford, III., Tropical Mariculture Technology, Inc., personal communications, April 8, 1991.

Appendix G2.--Colombia. Shrimp farms, 1989-90

Coast/Farm	1989			1990		
	Pond area*	Harvests	Exports	Pond area*	Harvests	Exports
	Hectares	Metric tons	US$ Million	Hectares	Metric tons	US$ Million
Caribbean						
Cartagenera de Acuacultura	400	646	4.0	400	1,300	8.0
Camarones del Caribe	145	215	1.0	200	700	3.5
Agrosoledad	98	360	2.1	180	600	3.0
Acuipesca	100	270	1.4	172	550	2.6
Colombiana de Acuacultura	100	165	1.0	185	420	2.3
Acuacultivos del Caribe	50	65	0.3	110	250	1.3
Agromarina Santa Ana	35	85	0.5	62	155	0.8
Agromarina Cispata	30	16	0.1	30	125	0.6
Langostinos Colombianos	50	50	0.3	50	110	0.6
Agrotijo	20	60	0.3	44	100	0.5
Cultimar del Caribe	30	40	0.2	70	70	0.4
Cruz Baru	12	20	0.1	12	26	0.1
Camarones de Uraba	-	-	-	-	-	-
Others	-	-	-	-	-	-
Subtotal, Caribbean	1,080	1,992	11.2	1,535	4,406	23.6
Pacific						
Agromarina Tumaco	42	27	Negl	42	179	0.3
Aquacultura America	-	-	-	60	132	0.7
Aquamar	132	200	1.1	166	420	1.8
Camaronera Balboa	104	182	0.7	113	231	1.1
Caribeña	44	25	0.1	90	173	0.9
Guinulero	40	25	0.1	47	103	0.5
Maragricola	240	301	1.8	320**	1,200	6.0
Mariscal	50	5	Negl	50	150	0.8
Pexco	80	55	0.3	80	80	0.4
Produmar	-	-	-	130**	225	1.1
Agua Clara	60	40	0.2	60	132	0.7
Expocali	80	41	0.1	80	90	0.5
Nautilus	30	30	0.2	30	132	0.3
Maja	30	20	0.1	30	132	0.3
La Perla del Pacifico	30	30	0.2	30	132	0.3
Others	-	-	-	-	-	-
Subtotal, Pacific	942	981	4.8	1,328**	3,511	15.6
Total	2,022	2,973	16.0	2,863**	7,917	39.1

* In production
** Some observers believe these estimates are excessive. See appendix F.
Note: Discrepancies with other ACUANAL data are unexplained.
Source: ACUANAL

Appendix G3.--Colombia. Shrimp farms, 1991

Coast/Farm	Pond area	Harvests	Exports
	Hectares	Metric tons	US$ Million
Caribbean			
Cartagenera de Acuacultura (Cartacua)	404	1,900	10.0
Camarones del Caribe	200	900	5.0
Colombiana de Acuacultura	172	640	3.8
Acuipesca	192	616♦	3.5
Agrosoledad	180	600♦♦	3.5
Aquacultivos de Caribe	126	600	3.0
Cultimar	120	540	2.5
Agromarina Santa Ana	62	216	1.2
Agrotijo	34	160	0.8
Ararca	45	120	0.6
Agromarina Cispata	38	104	0.5
Cruz Baru	10	16	0.1
Langostinos Colombianos*	-	-	-
Camarones de Uraba	-	-	-
Others	48	40	0.1
Subtotal, Caribbean	1,631	6,452	34.5
Pacific			
Aquamar	206	577	3.5
Maragricola	240	806	3.4
Camaronera Balboa	200#	400	2.0
Produmar	116	360	1.7
Caribena	100	236	1.1
Perla del Pacifico	100	400	1.0
Pexco	60	152	0.9
Guinulero	40	112	0.6
Mariscal	60	110	0.5
Inversiones Maja de Colombia	50	100	0.5
Agua Clara	68	68	0.2
Agromarina Tumaco	42	59	0.3
Acuacultura America	-	-	-
Nautilius*	(30)**	-	-
Inversiones Ururita	-	-	-
Exportadora Cali*	(80)**	-	-
Subtotal, Pacific	1,282	3,380	15.6
Total	2,913	9,832	50.1

♦ The company has revised its 1991 projection to about 680 tons. Pablo Andres Siegert Garcia, Gerente, Acuipesca, personal communications, May 14, 1991.
♦♦ The company has revised its 1991 projection to about 700 tons. Jose Vicente Mogollon Velez, Gerente General, Agrosoledad, personal communications, May 16, 1991.
* Harvested shrimp in 1989 and/or 1990, but reportedly inactive in 1991.
** Inactive in 1991
# The company reports a lower pond area of only 115 hectares.
Source: Clara Maria Sanin Posada, President, ACUANAL, personal communications, March 19, 1991.

Appendix G4.--Colombia. Principal Caribbean farms, 1990

Coast/Farm	Pond area	Harvest	Exports	Species
	Hectares	Metric tons	US$ 1,000	
Cartagenera de Acuacultura* (Cartacua)	390	1,329	7,020	Pv#,Pst
Agrosoledad	166	426	2,380	Pv##,Pst
Colombiana de Acuacultura**	158	338	1,616	Pv###,Pst
Acuipesca	173	618	2,776	Pv##,Pst
Camarones del Caribe (CAMCAR)***	165	644	3,000	Pv###,Pst
Aquacultivos de Caribe	199	287	1,394	Pv
Cultimar	59	95	708	Pv
Agrosantana	62	140	744	Pv
CRUSBARU	6	12	108	Pv
Granjas Marinas de Ar.	11	30	220	Pv
Agrocispata	NA	NA	NA	NA
Agrotijo	30	30	270	Pv
Maricultivos del Caribe	5	10	90	Pv
Total	1,424	3,959		

* CARTACUA
** COLAQUA
*** CAMCAR
\# 85 percent
\#\# 90 percent
\#\#\# 95 percent
Source: Source: Luis E. Martinez Silva, Coordinador Proyecto ACUIMAR, INDERENA, personal communications, March 11 and June 6, 1991.

Appendix H1.--Colombia. Shrimp hatchery production, 1990

Coast/Hatchery	Hatchery			Species
	Capacity	Production	Sales	
	1,000 Lts	Million pl	US$ 1,000	
Caribbean coast				
Camarones del Caribe (CAMCAR)*	120	104	832	Pv#,Pst
Cartagenera de Acuacultura (Cartacua)*	264	70	560	Pv*,Pst
Postlarvas del Caribe	119	42	360	Pv
INMARES	90	40	340	Pv
Hidrocultivos de La Costa	80	38	307	Pv,Unknown
Carlos McLean (TOLU)	80	35	298	Pv
CAPA♦	80	30	255	Pv
INDULARVA (Cienaga)	90	30	255	Pv
Rancho Chico	80	16	136	Pv#,St
Acacias del Mar	30	14	122	Pv
Prodularva** *	240	(100†)	125	Pv
Culcan	NA	6	NA	Pv
Agromarina Cispata	NA	NA	NA	Pv
Inversiones Camaroneras*	NA	NA♦♦	NA	Pv
CVS	NA	NA	NA	Pv
Postlamar	NA	NA	NA	Pv
Acuacultivos del Caribe (ACUARIBE)***	NA	NA	NA	Pv
Demares***	NA	-	NA	Pv
Others	NA	NA	NA	
Subtotal, Caribbean	NA	450##	3,590	
Pacific coast				
IDELPACIFICO	NA	175###	Pv	
Tigua	NA	180	Pv	
Post-Larvas del Pacifico***	NA	NA	NA	
NAPASA####	NA	NA	NA	
Universidad de Valle****	NA	-	Mr	
Others	NA	NA	NA	
Subtotal, Pacific	NA	355		
Total	NA	805♦♦♦		

Mr - Macrobrachium rosenbergii
Pst - Penaeus stylirostris
Pv - P. vannamei
* Maturation facility (Several sources confirm that CAMCAR, Cartacua, and Prodularva do maturation. One source suggests that Inversiones Camaroneras also does maturation, but this is not confirmed.
♦ Reportedly leased by Prodularva
♦♦ The company reports that a 1991 expansion program now gives it the capability of producing 144 million pl annually.
♦♦♦ Actual production was probably some what higher because estimates for several hatcheries were unavailable. It is likely, however, that 1990 production at most of these hatcheries was relatively limited.
* 85 percent
** Maturation hatchery which only sells nauplii.
*** Reportedly opened in 1991 and is offering pl for sale.
**** Under construction.
# 95 percent
Estimate
Projected 1991 production was 250 million postlarvae. Sanin, ACUANAL, personal communications, June 7, 1991. Virus problems at the hatchery during early 1991, however, have probably limited 1991 production to 175 million postlarvae. Javier Betancourt, Subgerente de Operaciones, personal communications, November 21, 1991.
NAPASA exclusively produces nauplii. The hatchery was operational in 1991, but may not have been in 1990.
† Nauplii
Note: Four hatcheries are reportedly producing Macrobrachium rosenbergii pl, but the identities of those hatcheries is unavilable.
Source: Luis E. Martinez Silva, Coordinador Proyecto ACUIMAR, INDERENA, personal communications, March 11 and June 6, 1991, and Jorge Pang, Agromarina, personal communications, May 27, 1991 (Caribbean Hatcheries). German A. Bolivar, Seccion Biologia Marina, Universidade del Valle, personal communications, January 22, 1991 (Pacific hatcheries). Clara Maria Sanin Posada, President, ACUANAL, personal communications, September 11, 1990 (Caribbean and Pacific hatcheries).

Appendix H2.--Colombia. Hatchery situation, 1990-91

Activity	Year	
	1990	1991E
	Billion nauplii/postlarvae	
Nauplii		
Installed capacity		
Caribbean	1.4	1.8
Pacific	0.5	0.6
Total	1.9	2.4
Production*		
Caribbean	0.8	1.5
Pacific	0.2	0.3
Total	1.0	1.8
Demand		
Caribbean	0.8	1.3
Pacific	0.5	0.6
Total	1.0	1.9
Postlarvas		
Installed capacity		
Caribbean	0.5	0.8
Pacific	0.3	0.4
Total	0.8	1.2
Production*		
Caribbean	0.3	0.5
Pacific	0.2	0.3
Total	0.5	0.8
Demand		
Caribbean	0.9	0.7
Pacific	0.3	0.4
Total	1.2	1.1
Defecit	0.7	0.4
Imports	0.7	NA

E - Estimated
* Includes imports
Note: The survival rate of nauplii is about 40 percent and the rate for pl is about 50 percent.
Descrepancies with appendix H1 are unexplained.
Source: Unsourced information sheet, presumably ACUANAL.

Appendix I1.--Colombia. Postlarval demand*, 2.0 harvests per year

Area	Stocking Densities			
	5pl/m2	10pl/m2	15pl/m2	20pl/m2
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.

Appendix I2.--Colombia. Postlarval demand*, 2.5 harvests per year

Area	Stocking Densities			
	5pl/m2	10pl/m2	15pl/m2	20pl/m2
Hectares		Billion pl		
500	0.08	0.16	0.24	0.32
1,000	0.16	0.32	0.48	0.64
1,500	0.24	0.48	0.72	0.96
2,000	0.32	0.64	0.96	1.28
2,500	0.40	0.80	1.20	1.60
3,000	0.48	0.96	1.44	1.92
3,500	0.56	1.12	1.68	2.24
4,000	0.64	1.28	1.92	2.56
4,500	0.72	1.44	2.16	2.88
5,000	0.80	1.60	2.40	3.20

* Calculations based on a 30 percent mortality rate.
Source: NMFS estimates.

Appendix I3.--Colombia. Postlarval demand*, 3.0 harvests per year

Area	Stocking Densities			
	5pl/m2	10pl/m2	15pl/m2	20pl/m2
Hectares		Billion pl		
500	0.10	0.20	0.30	0.39
1,000	0.20	0.39	0.59	0.78
1,500	0.30	0.59	0.88	1.18
2,000	0.39	0.78	1.18	1.56
2,500	0.49	0.98	1.47	1.96
3,000	0.59	1.17	1.78	2.34
3,500	0.69	1.37	2.05	2.74
4,000	0.78	1.56	2.34	3.12
4,500	0.88	1.76	2.63	3.52
5,000	0.98	1.95	2.93	3.90

* Calculations based on a 30 percent mortality rate.
Source: NMFS estimates.

Appendix I4.--Colombia. Estimated postlarvae demand, 1985-92

Year	Demand
	Billion pl
1985	0.1
1986	0.1
1987	0.3
1988	0.4
1989	0.6
1990	1.4
1991	2.0
1992	3.0

Note: The above figures are only rough estimates of approximate demand.
Source: Computed from data in appendices D and H1-3 and ACUANAL harvest estimates.

Appendix I5.--Colombia. Postlarvae supply, 1990

Source	Pl supply	
	Amount	Proportion
	Billion pl	Percent
Wild collection	0.1♦	6
Imports#	0.6	38
Hatcheries*		
Caribbean	0.5	31
Pacific	0.4	25
Total	0.9**	56
Total##	1.6	100

♦ For simplicity's sake, the round figure of 0.1 billion is used in this appendix. Some observers state that this probably overstates the importance of wild collections. One observer doubts if even 50 million (0.05 billion) pl is collected in Colombia.
The current trend is for hatcheries to import nauplii and then produce pl for growers rather than the growers to import postlarvae directly. Adding together pl and nauplii imports, probably over 70 percent of the pl was imported.
Totals may not agree due to rounding.
* Much of the hatchery production is based on imported nauplii, primarily from Panama and to a lesser extent Ecuador.
** Roughly confirmed by INVEMAR which estmates 0.8 billion pl. Frederico Newmark U., Coordinator, Mariculture Program, INVEMAR, personal communications, August 13, 1991.
Source: NMFS estimates

Appendix J1.--Colombia. Cultured shrimp exports, 1985-92

Year	Exports
	US$ Million
1985	0.6
1986	1.0
1987	2.4
1988	7.0
1989	16.0
1990	30.7
1991	50.1P
1992	53.0P*

P - Projected
* Several important farms are reporting better than expected harvests. As a result, these harvest projections may prove unrealistically low. This projection was received from ACUNAL March 19, 1991 and has probably now been revised upward.
Source: Clara Maria Sanin Posada, President, ACUANAL, personal communications, March 19 and June 7, 1991.

Appendix J2.--Colombia. Shrimp exports, 1980-90

Year	Exports		Total
	Capture	Culture	
	1,000 Metric tons		
1980	1.8	-	1.8
1981	1.5	-	1.5
1982	1.7	-	1.7
1983	1.2	-	1.2
1984	2.3	-	2.3
1985	2.2	0.1	2.3
1986	5.4	0.1	5.5
1987	4.3	0.2	4.5
1988	3.5	0.8	4.3
1989	NA	NA	NA
1990	NA	NA	NA

Note: Major discrepancies with Appendix L are unexplained.
Source: DANE/INCOMEX (1980-82 data) and INDERENA,INFOPESCA (1983-88 data).

Appendix J3.-- Colombia. Shrimp exports by country, 1980-90

Year	Country			Total
	U.S.	E.C*	Japan	
	1,000 Metric tons			
1980	1.5	-	0.4	1.9
1981	1.3	-	0.3	1.6
1982	1.3	-	0.3	1.6
1983	1.3	-	0.4	1.7
1984	1.6	-	0.5	2.1
1985	1.5	-	0.8	2.3
1986	2.0	0.3	1.0	3.3
1987	2.0	0.4	1.3	3.7
1988	1.9	0.8	1.4	4.1
1989	2.7	1.7	1.2	5.6
1990	3.7	2.9	1.4	8.0

*Includes Spanish data beginning in 1986.
Note: Major discrepancies with appendix K are unexplained.
Sources: U.S. Bureau of the Census, EC NIMEXE, and the Japan Tariff Association.

Appendix J4.--Colombia. U.S. shrimp imports, 1980-91

Year	Imports	
	Quantity	Value
	Metric tons	US$ Million
1980	1.5	13.3
1981	1.3	11.8
1982	1.3	14.5
1983	1.3	16.2
1984	1.6	18.5
1985	1.5	13.6
1986	2.0	18.1
1987	2.0	19.7
1988	1.9	18.6
1989	2.7	26.1
1990	3.7	31.2
1991	4.2P	NA

P - Projection, actual shipments through september totaled 3,400 tons.
Source: U.S. Bureau of the Census.

Appendix J5.--Colombia. U.S. shrimp imports by size count, 1990

Product/ Size	Imports	
	Quantity	Value
	Metric tons	US$ Million
Shell-on		
Under 15*	301.9	3.6
15/20*	164.7	1.4
21/25*	65.3	0.6
26/30	116.2	0.7
31/40	164.7	1.2
41/50	192.0	1.2
51/60	140.9	0.9
61/70	45.9	0.3
over 70	206.3	1.8
Unclassified♦	1,720.5	15.5
Peeled	557.8	4.1
Total#	3,676.0	31.2

* 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 the collection and processing the information, so the above data should be used with some reservation.
Source: U.S. Bureau of the Census.

Appendix J6.--United States. Monthly shrimp imports from Colombia, 1989-91

Month	Year		
	1989	1990	1991
		Metric tons	
January	184	365	286
February	128	361	360
March	135	223	228
April	155	257	463
May	244	342	462
June	267	286	502
July	219	297	463
August	342	399	401
September	179	289	259
October	381	228	
November	258	296	
December	236	334	
Total	2,728	3,676	4,200P

P - Projected, actual shipments through September have totaled 3,400 tons.
Source: U.S. Bureau of the Census.

Appendix J7.--EC. Shrimp imports from Colombia, by importing country, 1986-90

Country	Year				
	1986	1987	1988	1989	1990
			Metric tons		
Spain	260	431	691	1,493	2,273
France	-	-	22	46	220
Netherlands	-	-	17	97	218
Portugal	-	-	-	-	162
Italy	-	-	-	-	12
Germany	-	-	-	8	2
Belgium/Lux.	-	-	25	36	-
Total	260	431	755	1,680	2,887

NA - Not available
Source: EC NIMEXE

4.6

ECUADOR

Ecuador is the dominant producer of cultured shrimp in Latin America and the fourth largest producer in the world. The country is blessed with several attributes that make it an excellent location to culture shrimp, including plentiful stocks of an indigenous species appropriate for pond culture, a large area of coastal estuaries with suitable soil characteristics, extensive freshwater resources, and a tropical, albeit variable, climate. These factors have enabled growers to develop one of the Ecuador's most important industries.

Ecuadorean growers have carried out a massive pond construction program, building more than 100,000 hectares of ponds. As a result, cultured harvests and exports expanded significantly during the 1980s. Harvests increased from only 5 metric tons in 1979 to over 70,000 tons by 1990. Preliminary data suggest that harvests reached a record 100,000 tons in 1991. Most of the harvest is exported, primarily to the United States, but also to a rapidly expanding European market. Shrimp exports generated $340 million in foreign exchange earnings during 1990, and may have earned a record $425 million in 1991.

The industry appears to have made considerable progress in resolving seedstock shortages which periodically plagued it during the 1980s. The country has developed a major hatchery industry which has stabilized postlarvae supplies. Some observers also report that the quality of hatchery postlarvae has improved substantially. The hatchery industry, however, is not without problems. Many hatcheries report serious technical difficulties and growers continue to prefer wild seedstock when it is available due to its superior survival and growth characteristics.

Ecuadorean growers have the potential to significantly increase harvests during the 1990s if they can intensify operations and improve yields. Most Ecuadorean farms still report relatively low yields compared to other Latin American and Asian countries. Expanding Ecuadorean harvests during the 1980s were largely the result of increasing pond area, but observers now report only limited potential for further increases. Despite the limits on pond area, only minor improvements in pond management would result in very substantial harvest increases. Some observers insist that while Ecuadorean yields are relatively low, profit margins are favorable because of relatively low operating costs. Other observers are concerned that the industry will have to modernize pond management to remain competitive. Several obstacles, however, may hinder the industry's efforts to modernize. Lower real shrimp prices and higher operating costs have narrowed profit margins, making it more difficult for growers to afford pond modifications. Credit is difficult to secure and only available at very high interest rates. Higher quality feeds, necessary for more intensive operations, are difficult to obtain in Ecuador. Additional research must be undertaken and more trained personnel are needed to staff increasingly sophisticated hatcheries and growout operations.

Future industry trends are unclear. Some observers report progress in increasing yields; others insist that most growers have made little progress, and that the record 1991 harvest was due to higher stocking densities resulting from unusually abundant postlarval seedstock supplies. If growers succeed in making minor improvements in pond management and yields, Ecuador could achieve substantial harvest increases during the 1990s. It is likely that some improvement will occur, and growers should be able to achieve a harvest of at least 150,000 tons by the year 2000. If growers made progress in overcoming major problems, substantially larger harvests are possible.

CONTENTS

I. CAPTURE FISHERY

Ecuador conducts only a small trawler shrimp fishery; the majority of the country's shrimp production (over 90 percent) is cultured (appendix E1). Ecuadorean fishermen operated about 200 trawlers in 1988; the current number is unknown. Shrimp is fished all along the Ecuadorean coast, but most of the fleet operates in the southern Gulf of Guayaquil. A smaller fishery is conducted out of the northern port of Esmeraldas and the central port of Manta. The trawler catch is comprised mostly of white shrimp, though other species are also caught.[1] Marine shrimp catches averaged 8,100 metric tons (t) between 1985-89, ranging from a high of 10,800 t in 1988 to a low of 6,000 t in 1985. The 1990 catch was about 8,000 tons.

II. GROWING CONDITIONS

Ecuador offers generally favorable conditions for growing shrimp. The massive Guayas estuary offers a huge potential area for growout operations. Ecuador also has a ready supply of postlarval seedstock. These two factors together have given Ecuador a potential to culture shrimp that no other country in Latin America can match.

A. Climatic Patterns

Ecuador offers acceptable, but not ideal climatic conditions for culturing tropical shrimp. Southern Ecuador and northern Peru are the southern limits of the tropical *Penaeid* shrimp used by growers.[2] As a result, small climatic fluctuations can significantly affect growout conditions and postlarvae (pl) supplies. Ecuadorean water temperatures are influenced by a cold ocean current, the Humboldt Current, which runs along the northwest coast of South America. The infusion of cold water into Ecuadorean coastal waters limits the range of tropical species. An analysis of sea surface temperatures shows that Ecuadorean growers must deal with lower (21° C) and wider fluctuating (± 5° C) temperatures than growers in most other Latin American countries (appendix C).

Ecuador normally experiences a warm rainy season from January to April followed by a period of little or no rain and cool nights from May to December. Pl supplies tend to increase during the warm rainy season and decrease during the cooler dry season, although there is a substantial variation as a result of actual precipitation patterns. There is also a significant variability depending on the species.[3]

B. *El Niño* Events

Normal climatic patterns are occasionally disrupted by the global weather phenomenon known

Map 1.--*Map of Ecuador.*

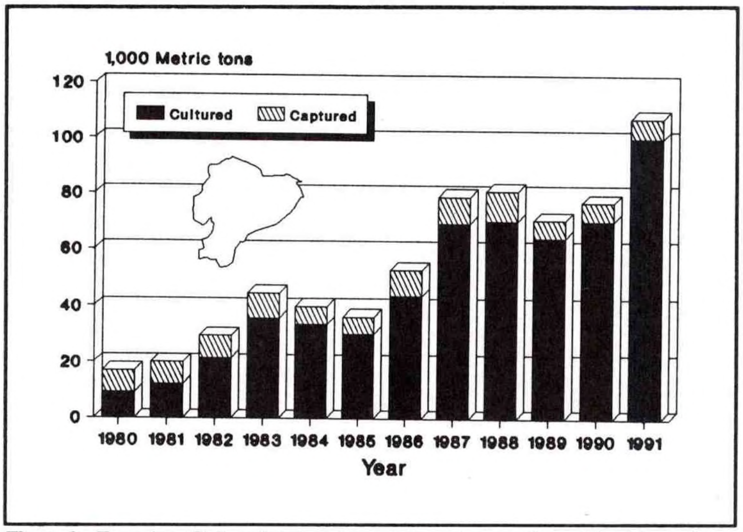

Figure 1.--Ecuador. Cultured shrimp harvests have increased considerably, and now comprise over 90 percent of Ecuador's total shrimp production.

as *El Niño*, which periodically manifests itself off the western coast of South America in the form of a full year or more of abnormally rainy, warm weather. The *El Niño* phenomenon follows a cyclical but unpredictable pattern, generally occurring every 4 to 5 years, although periods of up to 10 years sometimes separate events. The *El Niño* oceanic event can have a major climatic impact, both on temperature and precipitation, throughout Ecuador.

El Niño events can have a disastrous impact on the country as a whole. Ecuador experienced two *El Niño* events during the 1980s: 1982-83 and 1986-87. Rains from the 1982-83 *El Niño* caused floods that washed out roads, bridges, and power lines throughout the coastal region. Experts estimated damage at over $400 million. The 1986-87 *El Niño*, on the other hand, caused relatively little damage.[4]

The rainy, warm weather which accompanies an *El Niño* event provides ideal breeding and maturation conditions for tropical shrimp. The **heavy rains** increase the nutrient levels in coastal and estuarine waters because of expanded run-off from streams and rivers. Heavy rains also reduce salinities in the estuaries. The **warmer water temperatures** improve spawning conditions in the normally colder coastal waters. Tropical shrimp are extremely sensitive to even slight changes in water temperature.[5] These factors result in an abundant supply of pl and large wild shrimp populations.[6] This abundance allows growers to inexpensively stock available ponds, often at high densities, which permits them to achieve high yields. As a result of these factors, the 1982-83 and 1986-87 *El Niños* brought dramatic increases in cultured shrimp harvests (appendix E1 and figure 1).

The aftermath of both the 1983 and 1987 *El Niños* was remarkably similar. Both events were followed by periods of gradually falling rainfall and water temperatures, with accompanying declines in wild seedstock supplies.

First year later: In the first year after each *El Niño* (1984 and 1988), temperatures and precipitation were normal, with reduced pl supplies compared to the super-abundance of the preceding *El Niño* years.

Second year later: In the second year after each *El Niño* (1985 and 1989), rainfall and water temperatures were well below normal, and growers faced acute shortages and high prices for pl seedstock,[7] making it difficult to fully stock their ponds. In addition, cooler water temperatures, reduced nutrient levels, and higher salinities associated with these years reduced pond yields. Ecuadorean shrimp growers refer to these periods of below-normal temperatures and rainfall as *anti-El Niños* or *La Niñas*.

Third year later: Water temperatures returned to

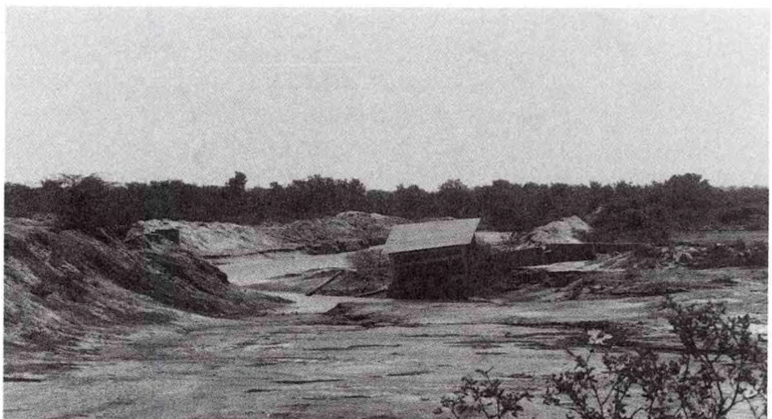

Photo 1.--Ecuador. El Niño events help growers by increasing pl supplies, but the heavy rains often associated with the event can damage farms. *Dennis Weidner*

normal in the first half of both 1986 and 1990, the third year following the 1983 and 1987 *El Niños*. The second half of 1986, however, was the beginning of the 1987 *El Niño*.

C. Water Quality

Water quality is a key factor for shrimp growers. The current situation in Ecuador is difficult to assess, as the authors have received varying reports. Some sources suggest that water quality is deteriorating.[8] Industry, academic, and press reports in early 1990 reported "alarming" pollution and water quality problems in Ecuador, claiming that virtually the entire shrimp culture industry in the Gulf of Guayaquil was experiencing disastrously high disease and mortality levels.[9] Shrimp exports for the first 2 months of 1990 were nearly 25 percent below their 1988 levels, giving some credence to these reports. Most local observers, including Government officials, however, were highly skeptical of reports describing an industry-wide disaster.[10] Their skepticism appears to have been justified by Ecuador's record levels of exports from September to December 1990, when shipments were greater than for any other 4-month period in the country's history.[11] While empirical data on water quality is not available, the record exports confirm that the industry as a whole remains highly productive. Some individual growers do seem to be experiencing disease and mortality problems. It is unclear if these problems are related to water quality as opposed to a variety of other possible problems associated with pond management and/or disease.

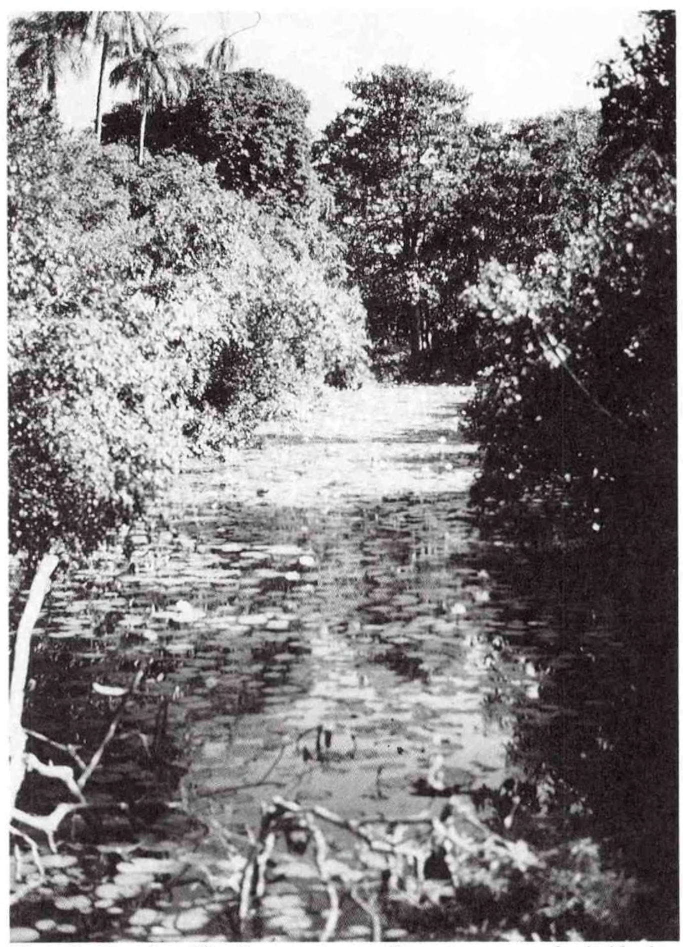

***Photo** 2.--Ecuador. The Guayas estuary offers a huge area of suitable sites, many with mangrove forestry.* *Dennis Weidner*

Despite conflicting opinions on the effect of pollution and shrimp farm yields, most observers agree that pollution levels in the Guayas River are high. The Guayas River Basin is the principal agricultural area in Ecuador. Guayaquil, Ecuador's major port and largest city, and other urban centers, are also located in the Guayas Basin. Substantial quantities of agricultural fertilizers and pesticides from rice and banana plantations, combined with expanding untreated industrial and urban sewage, are creating steadily increasing pollution levels. A contributing factor is runoff from the shrimp ponds themselves. Given the huge area of ponds, shrimp pond effluent contains large amounts of organic material.[12] This can have a significant environmental impact, especially in localized areas.

Low precipitation levels might have contributed to the 1990 water pollution problem. Normally, heavy precipitation during the January to April rainy season helps to dilute pollution. Increased water flow in the Guayas River helps to flush out the estuarine system, carrying the pollutants into the Gulf of Guayaquil. Unusually low rainfall during 1989 and early 1990 contributed to a higher concentration of polluted water flowing in Ecuador's extensive estuarine system. One observer noted that many farms reported sharply improved results after the rainy season began in the latter part of 1990.[13]

D. Mangrove Estuaries

Deforestation of mangrove areas poses a potentially serious problem. Many believe that the cutting of mangroves has seriously eroded environmental quality.[14] The nutrient-rich waters in mangrove estuaries provide ideal nursery habitat for juvenile shrimp and protect the shoreline from erosion during storms and heavy rains. In addition, mangrove areas act as a natural water filter, removing some pollutants. The Ecuadorean Chamber of Shrimp Producers estimated that shrimp growers, charcoal makers, and coastal developers destroyed more than 33,000 hectares (ha) of mangroves, or over 16 percent of the original area, between 1969 and 1987 (appendix D3).[15] The Ecuadorean Government recognizes the importance of mangroves to the long-term health of the country's shrimp industry and for years has attempted to limit pond construction that involved cutting mangroves. Government efforts to regulate construction, however, had little success, partly because of the complicated administrative processes. Officials now believe that they have effectively ended continued mangrove destruction. The Government totally prohibited the cutting of mangroves in 1989.[16] Government officials claim that this prohibition and revised regulations with a clear delineation of agency responsibility will at last provide effective protection for the mangroves.[17] It is unclear, however, if the resources are available for a vigorous enforcement of this policy or if the new measure is having any more effect than previous Government efforts.[18]

Photo 3.--*Ecuador. A Pacific white shrimp (Penaeus vannamei) is the preferred species for pond culture in most Latin American countries. © Willian Chauvin, Shrimp World*

III. SPECIES

Ecuadorean growers have focused almost entirely on marine species. Results with marine shrimp culture have been so profitable that few growers have been interested in conducting trials with freshwater species.

A. Marine

Ecuadorean marine shrimp growers have experimented with a limited variety of indigenous (appendix B) and exotic species. Successful commercial operations, however, are based almost exclusively on culture of an indigenous Pacific white shrimp (*Penaeus vannamei*). Over 95 percent of Ecuador's cultured shrimp harvest is *P. vannamei*.[19] Growers also report more limited success with another indigenous Pacific white shrimp (*P. stylirostris*), sometimes grown in combination with *P. vannamei*. Some reports suggest increasing interest in *P. stylirostris*, primarily because it appears to be more disease resistant. Trial runs with various other indigenous species, mostly *P. occidentalis*, have achieved largely negative results.

1. Indigenous

P. vannamei: This species of white shrimp occurs along the Pacific coast of Latin America from Mexico (Gulf of California) south to northern Peru. The maximum length is 23 centimeters (cm). Juveniles are plentiful in estuaries. 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, 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. Experimental runs showed it to be a highly aggressive species which consumes a wide range of plant and animal matter, including other species of juvenile shrimp. Trial runs performed at the NMFS Galveston Lab showed substantial differences between ponds stocked with *P. vannamei* and other species. The ponds stocked with *P. vannamei* had much cleaner bottoms because the shrimp had consumed plant and animal matter rejected by many other species.[20] These factors probably explains why the species does so well in ponds and is preferred by most Latin American shrimp farmers. *P. vannamei* has served as the basic species used by the highly successful Pacific-coast shrimp farmers. Farmers report that it performs well in both extensive and primitive semi-intensive systems and does well even with the inexpensive, relatively low-protein (20 percent) feeds currently available in Ecuador. (See Section X. Feed). As a result, researchers in Latin America and the United States have focused considerable attention on this species and there is a substantial and growing body of research on both hatchery and growout technology.[21]

P. stylirostris: This species of white shrimp is found from Punta Abreojos in Baja California south to Tumbes in Peru. Adults inhabit soft muddy clay or sandy bottoms from the beach to a depth of about 27 meters (m). The juveniles are generally found in bays and estuaries. The maximum length is about 23 centimeters. Some farms have used *P. stylirostris*, usually in conjunction with *P. vannamei*. Growers generally report low yields but are able to harvest larger, more valuable shrimp than with *P. vannamei*.[22] *P. stylirostris* is somewhat more tolerant of cold water temperatures than *P. vannamei*. Several Ecuadorean growers reportedly use *P. stylirostris* because it appears to be more disease resistant than *P. vannamei*. Most growers, however, still prefer *P. vannamei* because of it's superior pond survival and growth characteristics. *P. stylirostris* also requires higher quality feed than required for *P. vannamei*. Such feeds are costly and difficult to obtain in Ecuador. (See Section X. Feed). Many growers only use *P. stylirostris* when *P. vannamei* pl is unavailable.

P. californiensis: This species of brown shrimp occurs from San Francisco Bay in California south to Bahia de Sechura in Peru, although some reports extend its range even further south to Chile. It comprises only a small portion of the trawler catch. It is usually found at depths of 15-100 m, but is most abundant from 25-50 m on soft muddy or sandy bottoms. Juveniles are most abundant in offshore waters, especially at depths from 40-80 meters. 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 species performs poorly in ponds.

P. occidentalis: This species occurs from Chiapas, Mexico south to Peru. It reaches a length of 22 centimeters. *P. occidentalis* is an important species in the Ecuadorean capture fishery, but is not normally utilized by shrimp growers. The species does not perform well in ponds.[23] Growers note that although *P. occidentalis* is naturally present with other pl in estuarine water and in the pl delivered by collectors, few individuals survive, as the species is rarely reported in pond harvests.

2. Exotic

Ecuadorean growers have experimented with few exotic species. Their success with *P. vannamei* has provided little motivation to experiment with costly exotics. The only significant trials known to the authors have been conducted with *P. monodon*.

P. monodon: This species, commonly known as black tiger shrimp, is the most widely cultured species in the world, and dominates the Asian aquaculture industry,[24] with the exception of China.[25] Individuals can reach a length of nearly 36 cm, making it the largest of the major commercial species used by shrimp growers. *P. monodon* is an euryhaline species with a wide tolerance for salinity changes. Culture operations are somewhat complicated, however, by the uneven growth rates often experienced. Only a few Ecuadorean growers have experimented with *P. monodon*. Limited trial runs in 1986 and 1987 achieved disappointing results and growers did not initiate commercial-scale operations. *P. monodon*, like *P. stylirostris*, requires relatively high protein (40-45 percent) feeds which are difficult to obtain in Ecuador and would substantially

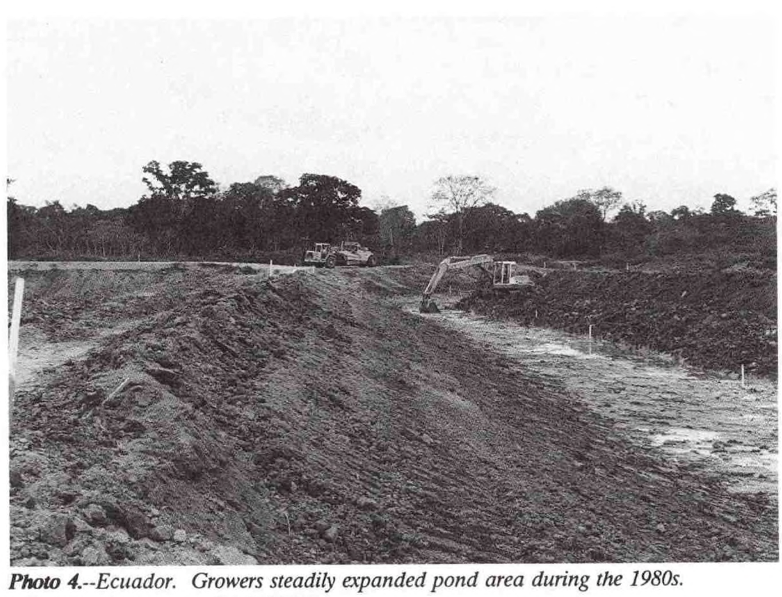

Photo 4.--*Ecuador. Growers steadily expanded pond area during the 1980s.*
© *Roberto Arosemena, BACHOCO*

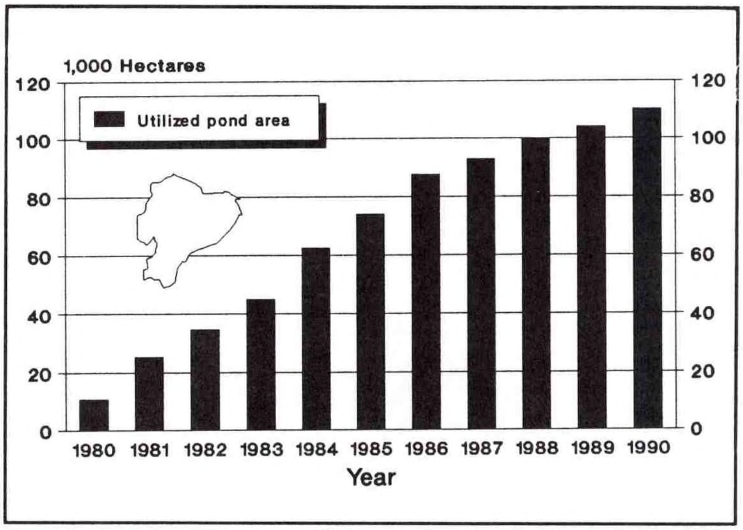

Figure 2.--Ecuador. Growers steadily increased pond utilization during the 1980s.

increase operating costs.[26]

B. Freshwater

The primary species of freshwater shrimp occurring in Ecuador is *Macrobrachium americanum*. Little is known about this species and no trials are known to have been conducted assessing its potential. A few growers have attempted limited trials with an exotic freshwater shrimp species, *M. rosenbergii*. None have reported commercial success. (See Section IX. Companies).

IV. AREA

The Government steadily increased authorizations for shrimp culture sites during the 1970s and 1980s. Only 440 ha of ponds were in production during 1976. New authorizations peaked between 1981-86, when an average of over 17,000 ha were approved each year. Additional authorizations for pond construction have slowed considerably since 1986. This is partially due to Government efforts to restrict further expansion because of environmental concerns,[27] but may primarily reflect the declining area of suitable sites remaining. Even without government action, pond construction probably would have declined. Authorized sites totaled 143,000 ha by 1989 (appendix D1). The total area actually in use, however, is substantially less than the total area authorized.[28] The actual area of active ponds in 1990 was around 110,000 hectares (figure 2).[29]

Ecuadorean ponds are heavily concentrated in certain areas. The greatest concentration of pond concessions is in Guayas province (70 percent) followed by El Oro province (20 percent). Only a small amount of land is authorized for shrimp ponds in Manabi and Esmeraldas (appendix D2).[30]

Ecuador has only a limited potential to expand total pond area. Most of the best areas in Guayas and El Oro have already been developed and additional ponds built on the less desirable sites now available may have difficulty competing in the current environment of increasing world shrimp production and falling real prices.[31] Some suitable sites still exist in the northern province of Esmeraldas. The area, however, is much more limited than in Guayas and development there is complicated by poorly developed infrastructure. One option for expansion during the 1990s would be to use currently abandoned farms. One estimate suggests that nearly 40,000 ha of constructed ponds are not being utilized. Many of these farms, however, cannot be adapted, even with engineering changes, as they were built on poor sites. Other farms were built on good sites, but were poorly designed and probably could be redesigned and reopened.

Photo 5.--Ecuador. Shrimp ponds currently total more than 110,000 hectares. © *William Chauvin, Shrimp World*

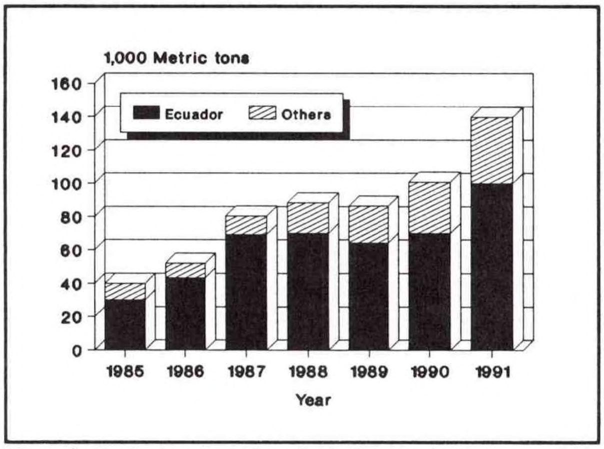

Figure 3.*--Latin America. Ecuador is the most important producer of cultured shrimp in Latin America, but harvests are expanding in other countries.*

V. HARVESTS

Ecuador's shrimp culture industry has developed into the fourth largest producer of cultured shrimp in the world (appendix E2) and the most important shrimp producer in Latin America (appendix E5 and figure 3). The shrimp industry is one of the most important sectors in the Ecuadorean economy; shrimp exports generated over $340 million in 1990.

1960s: Local observers trace the origins of Ecuador's shrimp culture industry to the early 1960s, when ranchers and plantation owners in the southern province of El Oro noticed shrimp in pools left by storms and unusually high tides. The exact circumstances of this discovery remain in dispute. Cultured shrimp began appearing in Santa Rosa and other local markets as early as 1967. The earliest documented records of the industry date from 1968, when the first commercial farm in El Oro province was built.[32]

1970s: The industry grew slowly during the 1970s. Growers with no technical background or experience with aquaculture experimented in primitive extensive trials. Harvests in the early part of the decade were negligible. Banks hesitated to make loans for this unproven new industry. It was not until the late 1970s that a few growers began reporting commercial success. This attracted new investors and the pond area began expanding. Growers by 1979 harvested nearly 5,000 tons.

1980-83: The pace of development quickened during the early 1980s. Growers harvested more than 12,000 t of cultured shrimp in 1981, an increase of 30 percent over the 1980 harvest. The 1983 harvest increased to nearly 36,000 t, a gain of 65 percent over the 1982 harvest, demonstrating the powerful impact of an *El Niño* event. During the early 1980s, growers replaced fishermen as Ecuador's primary shrimp producers. The growers' share of the country's total shrimp harvest rose from under 40 percent in 1979 to more than 80 percent by 1983. Growers optimistically projected rapid expansion, reporting low production costs and extremely favorable profit margins.

1984-85: Cooler temperatures and reduced rainfall in the years immediately following the 1983 *El Niño* caused an increasingly severe pl shortage which reached crisis levels in 1985. Local observers reported large numbers of idled ponds. Harvests fell from 35,700 t in 1983 to only 30,200 t in 1985, a 15 percent decrease. Many growers concluded that hatcheries were needed to supply postlarval seedstock, but the initial hatchery projects encountered serious technical problems. The Government responded by imposing a closed season on pl collection and temporarily suspended the construction of new ponds.[33]

1986-87: The appearance of another *El Niño* event in late 1986 brought abundant supplies of wild postlarvae. Growers began stocking idled ponds; as

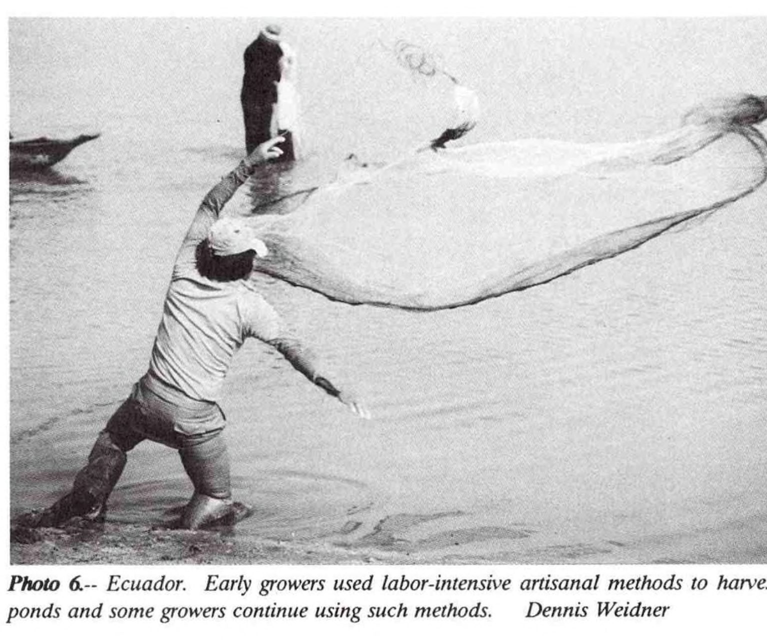

Photo 6.*-- Ecuador. Early growers used labor-intensive artisanal methods to harvest ponds and some growers continue using such methods. Dennis Weidner*

Photo 7.--*Ecuador. Harvests set new records in 1983 as a result of the 1982-83 El Niño. Dennis Weidner.*

Photo 8. Ecuador. Growers set an all-time record in 1991, primarily as a result of the 1991-92 El Nino. Dennis Weidner

a result, pond harvests increased dramatically in both 1986 and 1987. The 1987 harvest was over 69,000 t, more than double the 1985 harvest. Most of the increase was due to the reactivation of abandoned ponds and to higher stocking densities. Most growers continued to use the extensive methods; only a few growers began shifting operations to higher yielding semi-intensive methods.

1988-89: Local observers had predicted continued rapid growth for the industry in 1988 and 1989 following the record 1987 harvest. A return to normal rainfall and sea temperatures in 1988, however, caused the availability of wild pl to fall to normal levels. As a result, the expected increase in the 1988 harvest did not occur and growers only harvested 70,100 t, about the same as in 1987. Postlarval seedstock supplies declined in 1989 as temperatures and rainfall fell below normal. As a result, pond harvests declined to 64,200 tons.

1990: The 1990 harvest recovered to around 70,000 tons. Observers had initially predicted a poor 1990 harvest. Precipitation levels during the beginning of the year were substantially below normal, and growers reported pl scarcities and high disease mortalities. (See Section II. Growing Conditions). Harvests at the beginning of the year were so low that the Chamber of Shrimp Producers declared a state of emergency for the industry and pressured the Government for financial aid.[34] Harvests, however, rebounded during the second half of the year as rain returned to more normal levels, temperatures rose, and pl supplies increased.

1991: The favorable conditions that marked the second half of 1990 continued into 1991. Ecuador continued to experience warm temperatures and heavy rainfall,[35] the result of an emerging *El Niño* event. Some observers estimate a record harvest of about 100,000 tons. This increase is reflected in shipments of Ecuadorean shrimp to the United States, which totaled 48,800 t in 1991, a 30 percent increase over the 38,300 t shipped in 1990.[36] The increased harvests are partly due to abundant pl supplies, which have enabled growers to use idled ponds and increase pond stocking densities.[37]

1990s: Any continued increase in harvests depends primarily on the industry's success in improving pond yields. Relatively little potential exists to further expand pond area. Some Ecuadorean growers, however, are optimistic. One observer reports that the Ecuadorean shrimp culture industry has set a production goal of 140,000 t for 1994.[38] Given the area of existing ponds, only a slight increase in yields could bring about major harvest increases. Projections of 150,000 t or more by 2000 seem possible if growers can improve yields. While many growers use higher stocking densities when pl prices fall, few extensive growers appear to be making the

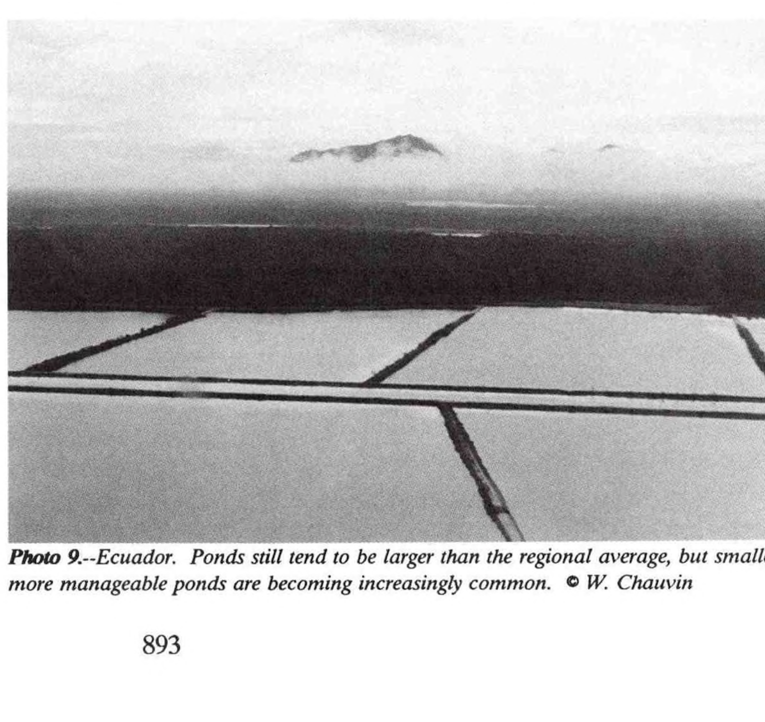

Photo 9.--Ecuador. Ponds still tend to be larger than the regional average, but smaller more manageable ponds are becoming increasingly common. © W. Chauvin

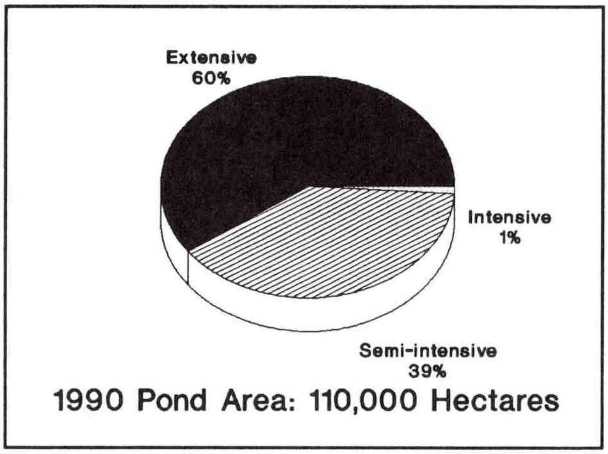

Figure 4.--Ecuador. Most growers continue to utilize extensive culture methods.

costly farm design changes that would enable them to shift to higher yielding semi-intensive methods. The lack of progress in improving methods and yields during the 1980s suggests that major advances during the 1990s are not assured.

VI. METHODS/YIELDS

Ecuador's shrimp culture industry was founded by growers using extensive culture methods. The rapid growth of the industry during the 1980s has come principally as a result of the increase in production area and not from any widespread improvement of methods and yields.[39] Some important operations have built modern, semi-intensive farms, but extensive farms still dominate pond area and continue to be a very important part of the industry (appendix G2 and figure 4). Thus, while Ecuadorean growers still harvest most of Latin America's farmed shrimp, average yields are below those reported in several other Latin American countries.[40] While Ecuador continues to be the primary Latin American producer (figure 3), the proportion of cultured shrimp harvested in Ecuador compared to other Latin American countries has been steadily decreasing (appendix E6).

Extensive methods: Most Ecuadorean farms continue using extensive culture methods. Extensive culture entails low pl stocking densities and relies on natural tidal and river flows for water exchange and to supply nutrients. Often individual ponds are quite large, in some cases exceeding 100 hectares. While yields at these farms average only about 0.4 t per ha, this is offset by low production costs. Approximately 60 percent of Ecuador's total pond area was extensive farms in 1987, but these farms only produced about 35 percent of the country's total cultured shrimp harvest (appendix G2). While the technology is primitive, some observers insist that this is not necessarily a disadvantage, especially in developing countries.

Semi-intensive methods: Almost all of the remaining farms use semi-intensive methods. Semi-intensive farms have much smaller ponds to permit more careful pond management. Growers generally use supplemental feeds, higher stocking densities, and increased water exchanges. Semi-intensive farms, as a result, require greater capital investments, but return much higher yields, averaging around 1.1 t per hectare (appendix G2).[41]

Intensive methods: Ecuadorean growers have expressed little interest in intensive methods, given the substantial investments required and the profitability to date of extensive and semi-intensive operations. The Chamber of Shrimp Producers reports a few experimental intensive operations, but they total a negligible 200 ha, only about 0.2 percent of Ecuador's overall pond area. Intensive culture is the most sophisticated and high-cost method of shrimp farming. True intensive operations use small ponds (1-10 ha) and employ very high stocking densities (80-500 pl per meter).[42] Great attention is given to pond management; factors such as feeding,

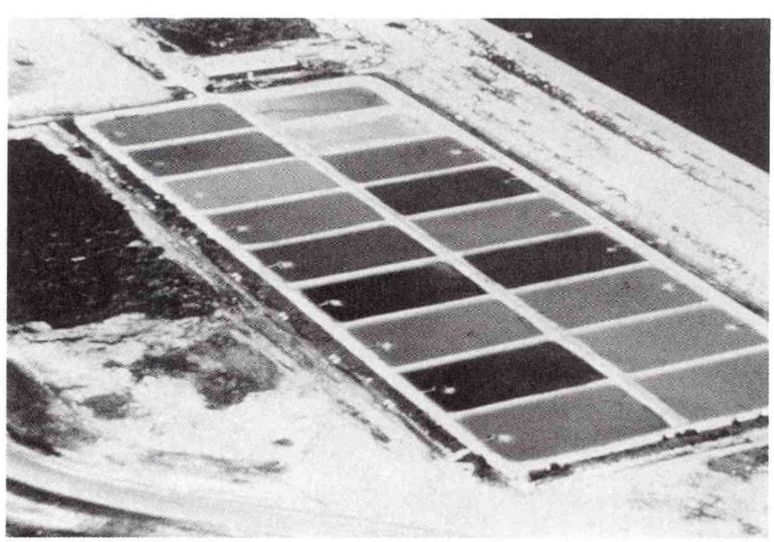

Photo 10.--Ecuador. Growers are attempting various innovations to imporve yields like these experimental ponds. © Mark Newman, Rangen

water control, temperature, waste removal, and aeration are carefully monitored and controlled. Growers are concerned about the increased possibility of disease in high density operations.[43] Intensive operations do not appear to take advantage of the many of Ecuador's natural advantages, but actual cost/benefit analysis are not available to fully assess the feasibility of such operations.

As a result of the large number of extensive farms, Ecuador reports lower overall yields than most important shrimp culturing countries in both Asia and Latin America. Ecuador has lower average yields per ha than China and Thailand but higher average yields than Indonesia (appendix E3). The average yield for the Ecuadorean industry as a whole was approximately 0.7 t per ha in 1990, compared to 1.0 t per ha in China, 1.8 t per ha in Thailand, and 0.4 t per ha in Indonesia.[44] Ecuadorean yields in recent years have fallen behind yields reported in other Latin American countries developing important shrimp culture industries (Colombia, Guatemala, Honduras, and Peru).[45]

Few established Ecuadorean growers appear to be making the commitment to intensifying farm operations, and the Government has made no efforts to encourage this. In many instances this would require costly construction projects, especially dividing large extensive ponds into smaller, more manageable units. Some observers believe that such modifications, however, may be required if Ecuador is to remain competitive with increasingly efficient operations in Asia and Latin America. Only limited information is available, however, on the economics of extensive, semi-intensive, and intensive operations. Some Ecuadorean observers insist that the costly investment required to upgrade extensive farms may not be justified, especially if semi-intensive operations cannot generate yields above the 1.1 t per ha average currently being reported in Ecuador. Growers in several Latin American countries report yields substantially higher than 1.1 t per hectare.[46]

There are indications that Ecuadorean yields increased during the first 6 months of 1991. One observer reports that yields increased considerably, primarily because of the ready availability of pl which permitted higher stocking densities. Growers have reportedly increased the stocking density from 5-7 pl per square meter to 10 or more pl per square meter.[47] There are no indications, however, of any widespread movement by growers to adopt more advanced technical techniques (such as smaller ponds, aerators, or improved feeds) to increase yields. As was the case during previous *El Niño* events, improving 1991 yields appear to be the result of increased supplies of pl and higher stocking densities.

Polyculture: Several Ecuadorean companies are reportedly experimenting with the cultivation of multiple species. Some observers believe that the number of companies utilizing polyculture methods will increase as growers seek ways to cope with rising production costs. Polyculture may offer growers the chance to increase their pond's profitability without costly pond modifications. Sensini, an Ecuadorean shrimp culture consulting firm, has received an EC grant to operate an experimental shrimp/clam farm using *M. mercenaria* and *T. semidecussata*.[48] One observer reports that predator species commonly found in shrimp ponds, such as *Centropomus unionesis* and *C. nigrescens* (seatrout and corvina) and *Cynoscion spp.* (snooks) could be harvested for domestic and international markets.[49]

VII. DISEASE

Diseases are a potential problem that all aquaculturists around the world confront. Commercial shrimp farming is a very recent development, but serious outbreaks have already been reported in several countries. The most serious outbreak to date occurred in Taiwan,[50] but several other countries have also reported difficulties. These problems have been primarily reported in Asian countries which have steadily increased the intensity of their cultured systems, thus creating favorable conditions for various disease pathogens. Disease outbreaks have also affected Latin American shrimp hatcheries and farms, resulting in varying mortality rates and lower harvests. These outbreaks have, however, been poorly documented and diagnosed. Scientists report that diseases are present in all wild and cultured shrimp. Massive losses due to disease outbreaks can occur in the aquaculture environment where stocking densities are much higher than in the wild. The animals are thus subjected to abnormally high stress levels, making them more susceptible to disease. In addition, the high stocking density makes it easier for a disease to spread through a population. Finally, because shrimp farms normally culture only one species, a disease which strikes that species can have a devastating effect on the entire pond. This can lead to very high mortality rates.

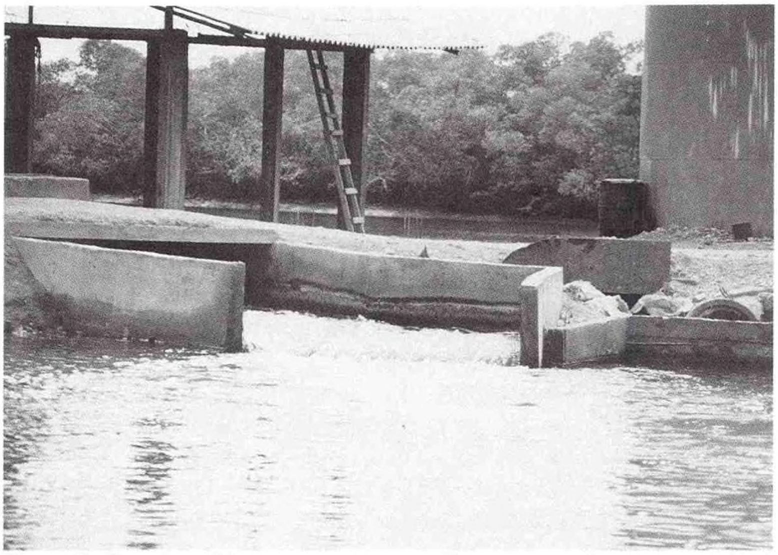

Photo 11.--Ecuador. Diseases can adversely affect growers. The best approach is improved pond management, especially water regulation. Dennis Weidner

Reports on the disease problem vary. A detailed assessment of the problem in the country is not available. Only a small number of experts worldwide specialize in shrimp disease. As a result, most problems are probably not accurately diagnosed. Some growers may report disease problems when the real cause is faulty pond management, such as the use of poor feeds or stocking beyond capacity. Some observers claim that Ecuadorean growers have exaggerated the severity of the disease problem in order to receive Government assistance.

Observers report several conditions in Ecuador that are causing disease outbreaks. One increasing concern is declining water quality as a result of rising pollution levels. (See Section II. Growing Conditions, C. Water Quality). Pollution makes shrimp more vulnerable to disease. Observers reported high contamination levels in the Gulf of Guayaquil during early 1990. Rising pollution levels and the huge area of ponds suggest that disease outbreaks may become an increasingly serious problem in Ecuador.

The Ecuadorean shrimp culture industry will probably continue to experience disease problems. It is unlikely, however, that the country will face an epidemic such as the one that devastated the Taiwanese shrimp culture industry in the late 1980s. Ecuador's large number of extensive ponds with low stocking densities makes the industry as a whole less vulnerable to disease outbreaks than countries with a large number of semi-intensive or intensive operations. Disease outbreaks will continue to occur in Ecuador, however, especially if water quality continues to decline or if growers fail to improve pond management standards.

VIII. PRODUCTION COSTS

Little information is available on Ecuadorean production costs. Such statistics are compiled by individual companies and generally kept as confidential information and thus not generally available for review. In many cases, available data was compiled in a variety of ways, making it difficult to make meaningful comparisons. The limited available information suggests that Ecuadorean growers during the mid-1980s reported some of the lowest production costs in the world as a result of the country's favorable environmental conditions and low-cost extensive methods. Scattered reports suggest 1991 production costs ranging from \$2.50-4.00 per kilogram (kg).[51] This compares favorably to Thailand, the Philippines, and other major competitors.[52] One exception may be China. The authors are unable to compare production costs between Chinese and Ecuadorean growers. This is especially important to Ecuadorean

Photo 12.--Ecuador. Some growers report extremely low production costs. © Lee Lippert, Lippert International

growers, as China is the only Asian country culturing large quantities of white shrimp and thus the principal competitor to Ecuadorean and other Latin American growers. China exports shrimp at prices substantially below Ecuadorean prices, suggesting lower production costs. This may not be the case, however, as China's command economy may distort costs of major inputs, thus affecting grower costs.[53] Such speculations, however, are highly conjectural, as the authors do not have the statistical data required to make any valid assessment.

Available information suggests that Ecuadorean profit margins are narrowing. One 1989 study showed healthy average profit margins of more than 20 percent above costs[54] (appendix G4). While this may appear substantial in U.S. terms, it is well below the much larger margins that shrimp growers were previously reporting and the general expectations of Ecuadorean investors. More recently, a variety of observers suggest that profit margins are narrowing. The Chamber of Shrimp Producers claims that Ecuadorean production costs have risen substantially. The Chamber claims that the Index for Shrimp Industry Costs (ICIC) has been rising at a faster rate than the overall Ecuadorean Consumer Price Index (ECPA). Government exchange rate policies have further squeezed margins. (See Section XIII. Government Role). Ecuadorean growers have not been able to offset the rising production costs with price increases, as the real price of shrimp in major world markets declined sharply during the 1980s (appendix F3 and figure 5).

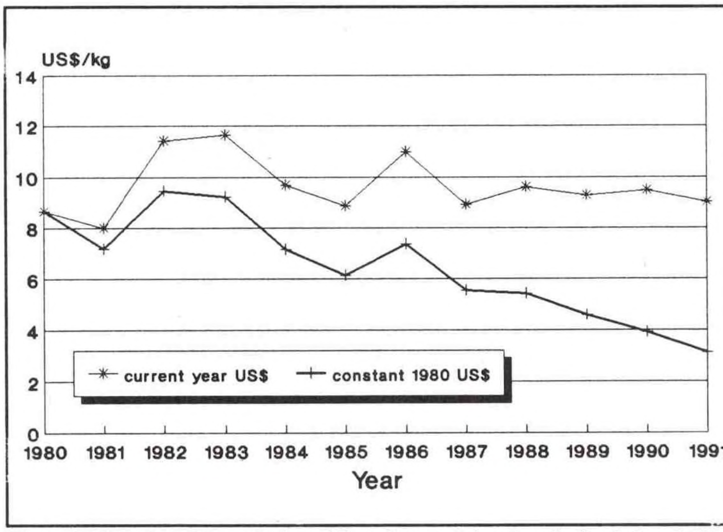

Figure 5.--Ecuador. The real price of Ecuadorean shrimp has declined sharply since 1980.

IX. COMPANIES

Ecuadorean growers have built a large number of farms with ponds covering a vast area of coastal land. The country probably had more than 80 percent of the operating commercial shrimp farms in all of Latin America during the 1980s.

A. Marine

Over 1,400 marine shrimp farms are currently operating in Ecuador. Most (90 percent) are located in the southern Gulf of Guayaquil area (Guayas and El Oro provinces). The remaining farms are located along Ecuador's central and northern coast in Manabi and Esmeraldas provinces (appendix D2). Most farms are relatively small operations; over 75 percent of Ecuador's farms have less than 100 ha of ponds, while fewer than 10 percent have more than 200 hectares (appendix G3).

Available information on important individual farms (appendix G1) is as follows:

Amorient Group: Amorient, a U.S. partnership, operates 500 ha of semi-intensive ponds; the 1991 harvest was around 1,200 tons. The company reports that 14 out of its 42 ponds could be considered highly semi-intensive due to their elevated stocking densities. Amorient reports 1991 yields of around 2.3 t per ha at the semi-intensive ponds and 4.5-5.5 t per ha at the highly semi-intensive ponds, one of the highest yields reported at any major Ecuadorean farm. All of Amorient's ponds are stocked with pl produced in the company's own hatchery, which produces over 30 million pl per month. The hatchery also supplies nauplii to neighboring farms.[55]

Aquamar: Aquamar operates 500 ha of semi-intensive ponds. The 1991 harvest was 1,100 t, or 2.2 t per hectare. The company obtains almost all of its pl from its own hatchery, Aqualab, which produces 40 million pl per month. Aquamar exports over 80 percent of its shrimp to Europe.[56]

Cosemar: Cosemar, which formerly operated 700 ha of semi-intensive ponds, was closed in 1990-91 for renovations. Cosemar continues to operate its hatchery, Indularva, and reports 1991 production of 25-30 million pl per month.[57] Cosemar, in late 1991,

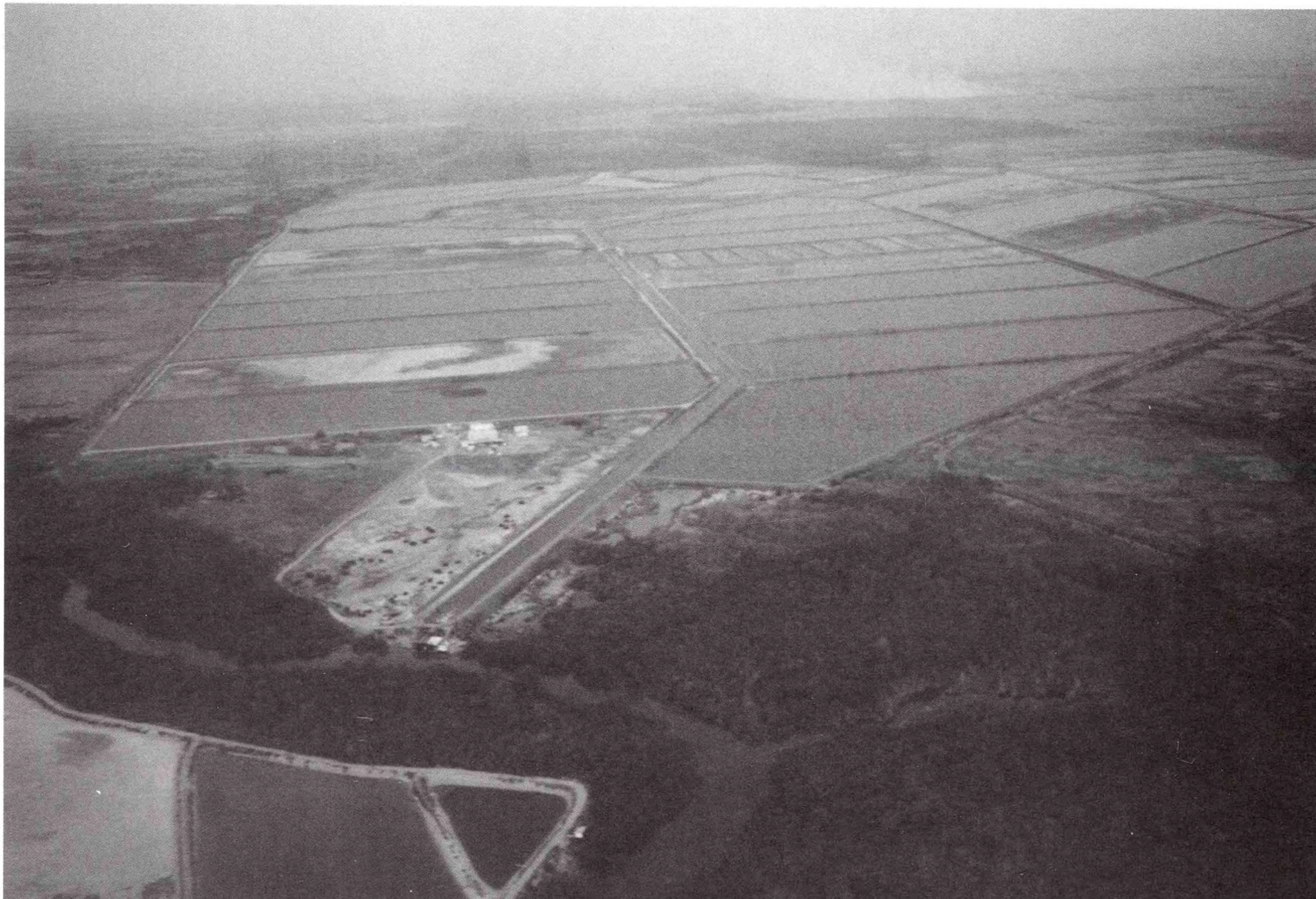

Photo 13.--*Ecuador. Aerial view of the Amorient Acuespecies farm showing freshwater sources, the main canal, and growout and nursery ponds.* © *Amorient*

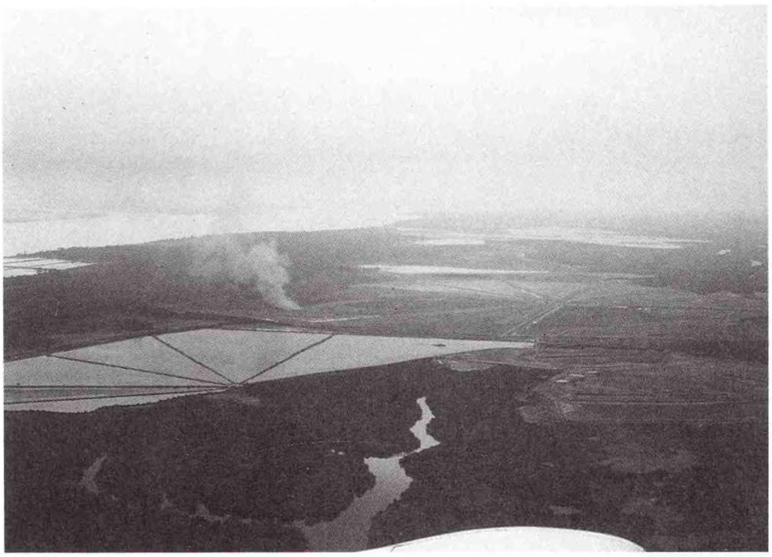

Photo 14.-- *Ecuador. Growers employ a wide range of farm layouts and operating systems. Dennis Weidner*

also began to produce its own feed under the "Inducam" brand.

Ecuamar: Ecuamar operated around 800 ha of semi-intensive ponds during 1991 out of a total of 1,500 ha which have been constructed. The 1991 harvest was 1,000 t, or 1.3 t per hectare. The company also operates a hatchery, Accionista, which produces an average of 50 million pl per month. Half of the pl used to stock the company's ponds comes from its hatchery, the other half is wild pl purchased from collectors.[58]

El Rosario: El Rosario is Ecuador's second largest farm. The company operates nearly 3,100 ha of extensive and semi-intensive ponds, as well as a small experimental intensive operation. The 1990 harvest was about 2,500 t, or 0.8 t per hectare. The company, however, is reportedly intensifying its operations. Company officials estimate that the 1991 harvest was 5,000 tons, or 1.6 t per hectare. El Rosario also operates three hatcheries, which produced a total of 150 million pl per month. The hatcheries provide around 85 percent of the pl used to stock the company's ponds. El Rosario processes its own product under the "Humboldt" brand.[59] The company is Ecuador's third largest exporter, with earnings of over $26 million in 1990 (appendix I11).

Empacadora Nacional: Empacadora Nacional is one of Ecuador's most established shrimp companies. It has been purchased by the U.S.-based Ground Round Restaurants. The company operates 870 ha of semi-intensive ponds. The 1990 harvest was around 800 t, over 0.9 t per hectare.[60] Empacadora Nacional is one of Ecuador's leading exporters, with 1990 earnings of nearly $21 million (appendix I11).

Lagoscorp: Lagoscorp operates 640 ha of semi-intensive ponds (out of 850 ha constructed). The 1991 harvest was 1,000 t, almost 1.6 t per hectare. Lagoscorp obtains all of its pl from its own hatchery. Production is reportedly 18 million pl per month.[61]

Langostino Group: The Langostino Group operates 700 ha of semi-intensive ponds. The 1990 harvest was 630 t, or 0.9 t per hectare.

Morrison Group: The Morrison Group operates 1,000 ha of semi-intensive ponds, as well as 300 ha of intensive ponds. The company's 1991 harvest was reportedly 3,300 t, or an impressive 2.5 t per hectare. The company produces most of its pl (90 percent) at its own hatchery, Semaqua, which produces over 38 million pl per month. The company also purchases small amounts of wild pl from collectors to supplement the hatchery production. Morrison operates its own packing plant and feed mill.[62]

Perez Group: The Perez Group operates the Langomorro farm, which has 650 ha of semi-intensive ponds. The 1990 harvest was 600 t, or 0.9 t per hectare.

Quirola Group: This company operates around 6,500 ha of ponds, the largest single operation in Ecuador or any Latin American country. The company uses largely extensive methods, but achieved favorable yields of over 0.9 t per hectare. The 1990 harvest was around 6,000 tons. Quirola reportedly operates seven hatcheries, but pl production is unknown.[63]

Vannoni Group: The Vannoni Group operates the Camaronera Cachugran farm, with 2,000 ha of semi-intensive ponds. The 1990 harvest was around 1,400 t, or 0.7 t per ha--relatively low for semi-intensive operations.

B. Freshwater

Ecuadorean attempts to culture freshwater shrimp have been limited. Several groups reportedly have studied the feasibility of growing freshwater shrimp, but no details are available on the results achieved.[64]

Photo 15.--Ecuador. *Many farms still apply feed by hand from small boots. © Yosuke Hirono, PENTEC*

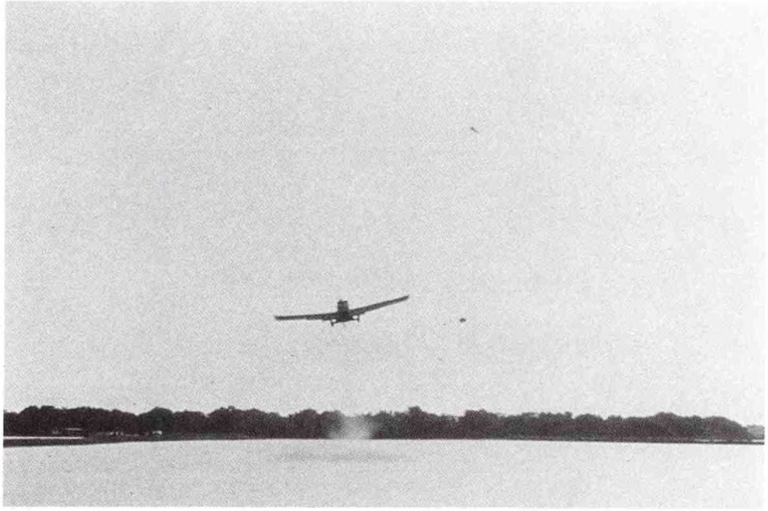

Photo 16.--Ecuador. *Some farms use small planes to apply feed. © Yosuke Hirono, PENTEC*

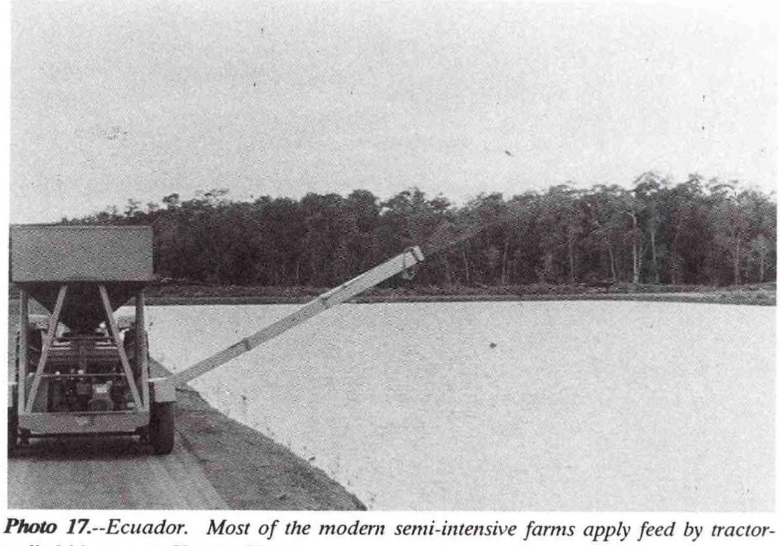

Photo 17.--Ecuador. *Most of the modern semi-intensive farms apply feed by tractor-pulled blowers. © Yosuke Hirono*

Photo 18.--Ecuador. Hand feeding in a large extensive pond. © *Lee Lippert, Lippert International*

One observer reports that 400 ha of freshwater ponds were active in 1989.[65] Freshwater shrimp growers, however, have reported problems in marketing their product. For this reason, and also because of the highly favorable results already achieved with marine operations, most growers have given little consideration to freshwater culture.

X. FEED

Ecuador has the largest shrimp feed industry in Latin America with 25 operating mills. The mills produce the inexpensive but relatively low protein content (20-25 percent) feeds that yield acceptable results with *P. vannamei*. The country's total shrimp feed output was about 54,500 t in 1988. More current data are not available.[66]Ecuadorean feed demand is still limited because of the large number of extensive farms which use little or no supplemental feed.

Ecuadorean feed demand fluctuates depending on the profitability of the shrimp culture industry. Demand, for example, declined substantially in 1989 because shrimp producers--facing scarce pl seedstock, increasing production costs, and lower real shrimp prices--discontinued or reduced supplemental feeding to limit operating costs.[67]

Ecuadorean-produced shrimp feeds are still relatively basic and some growers complain that the quality is generally poor. Few innovations, such as binders, have been adopted. As a result, domestic feeds have the drawback of breaking down rapidly after application. This leads to two problems. First, a large amount of feed is wasted because it dissipates before the shrimp can find and ingest it.[68] As a result, many farms report poor conversion ratios. Second, the feed not ingested by the shrimp pollutes the water. Large amounts of organic material accumulate on the pond bottom or are discharged in pond effluent. Improper use of feed can substantially increase the quantity of organic material, which can lead to a variety of pond management problems.[69] Little information is available to the authors about domestic feed mills. There does not appear, however, to be any major industry initiative to upgrade the quality of domestic feed production.

The principal growers and research institutions have carried out some studies evaluating feed composition, preparation, and application.[70] Growers report, however, great inconsistency in feed quality. Feed producers have reportedly downgraded or replaced ingredients as agricultural prices rise. This can result in substantial variations in the feed from a given company. No institution--public or private--currently monitors feed quality.[71] The larger growers are able to carry out tests, but small-scale operators have to accept advertised standards.

XI. POSTLARVAL SEEDSTOCK SUPPLIES

One of the key factors which has contributed to the success of the Ecuadorean shrimp culture industry has been the abundant supply of wild pl which growers could easily collect to stock their ponds. Growers in many other countries had the costly and technologically demanding problem of building sophisticated hatcheries to produce seedstock. Ecuadorean growers, however, were able to develop their industry with inexpensive pl collected by artisanal fishermen. This was a great advantage during the early stages of the industry's development and also helps current growers limit production costs. The massive expansion of pond area, however, created such an increase in demand for pl[72] that it could not be met solely by wild collection alone. In addition, the widely fluctuating annual availability of wild pl due to climatic changes has created serious

Photo 19.--*Ecuador. Wild pl availability fluctuates widely as a result of climatic conditions. Dennis Weidner.*

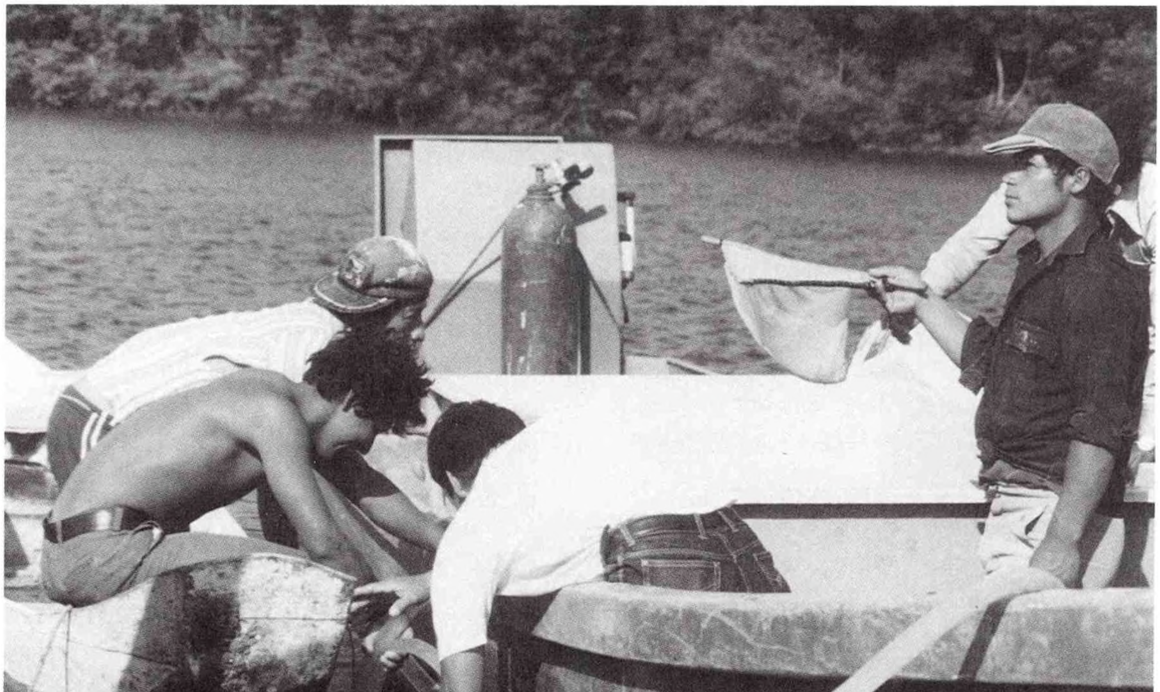

Photo 20.--*Ecuador. Collectors have made considerable improvments during the 1980s. Dennis Weidner*

Photo 21.--Ecuador. Collectors carefully monitor the condition of the pl during the transport phase. © *Dennis Weidner*

shortages. These shortages have led since 1985 to the development of a major hatchery industry, the largest in Latin America. Ecuadorean hatcheries now produce substantial quantities of *P. vannamei* pl and have become an important source of postlarval seedstock. The industry, however, still faces a variety of problems.

A. Wild Collection

Ecuadorean growers, during the early 1980s, relied on wild pl collected by artisanal fishermen to stock their ponds. This provided growers a ready source of inexpensive seedstock without having to make costly investments in technologically demanding hatcheries. Artisanal fishermen collect pl in fine meshed scissor nets along beaches and coastal areas. The early collectors had little experience or equipment to properly find and transport pl, and mortalities in the collection and transportation phase were substantial. As the industry has developed, pl collectors have steadily improved both their collection and handling methods. Collectors have identified areas where pl are most abundant, especially areas with high concentrations of *P. vannamei* postlarvae. Operations now include sophisticated communications and the use of small planes to pinpoint promising locations.[73] Most collectors have high-speed launches, as well as oxygen equipment to increase the survival rate. Nevertheless, some observers believe that substantial quantities of pl (as much as 50 percent of the pl collected) are still lost in the collection and transportation process before delivery to growers. One observer suggests that further improvements--such as using floats to prevent nets from dragging along the bottom and using holding tanks--could substantially increase survival rates with only minimal investments.[74]

The availability of wild pl is significantly affected by climatic conditions. Climatic changes have led to wide fluctuations in wild-pl abundance. Shortages, especially during the 1985 *anti El Niño* event, caused major economic dislocations, leading growers to idle ponds and reduce stocking densities. This encouraged many growers to look to hatcheries as an alternative source of postlarvae. Hatchery operators have succeeding in substantially increasing pl production and in offering growers a more reliable supply. Growers generally prefer wild pl when it is available, however, claiming that it survives and grows better than hatchery postlarvae. This is reflected in the higher prices wild pl commands over hatchery postlarvae (appendix H2).

B. Hatcheries

The Ecuadorean shrimp industry began devoting serious resources to hatchery construction after the 1984-85 pl crisis. A few important growers had launched hatchery projects previously, but achieved only marginal results. Until the 1984-85 pl shortage Ecuador had only four operational hatcheries producing less than 0.3 billion postlarvae.[75] The early hatcheries were designed as large, relatively sophisticated maturation facilities and ran into considerable problems. Many were poorly designed, which is not surprising, considering that few groups in any country had previously attempted commercial hatchery operations for *P. vannamei*. Shrimp maturation was a relatively new field and few specialists, even in technically advanced countries, had extensive experience in *P. vannamei* maturation. Initial results were disappointing. The hatchery industry, however, expanded rapidly, spurred on by the 1984-85 pl crisis.[76] By 1986, nearly 40 hatcheries were operating and producing about 2.0 billion pl annually.[77] By 1990, the industry had expanded to 150 hatcheries producing about 8.0 billion pl (appendix H1 and figure 6).[78] According to one observer, hatcheries produced up to 75 percent of the pl used to stock Ecuador's ponds in 1990, making them the country's primary source of seedstock.[79]

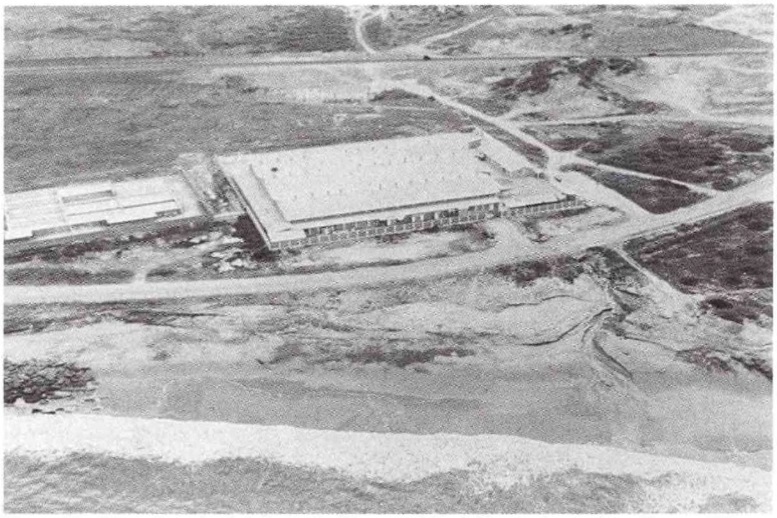

Photo 22.--*Ecuador. Aerial view of a high-tech Ecuadorean hatchery.* © *Yosuke Hirono, PENTEC*

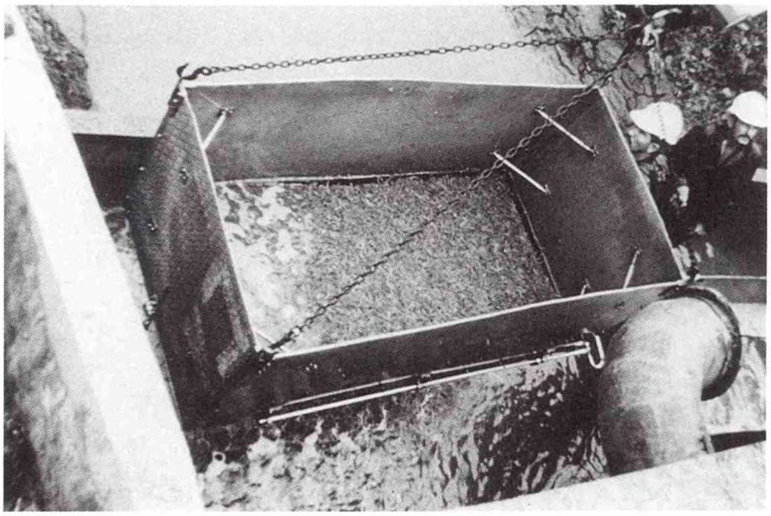

Photo 23.--*Ecuador. Collecting juvenile shrimp in the harvest basin of a nursery unit for stocking a growout pond.* © *Yosuke Hirono*

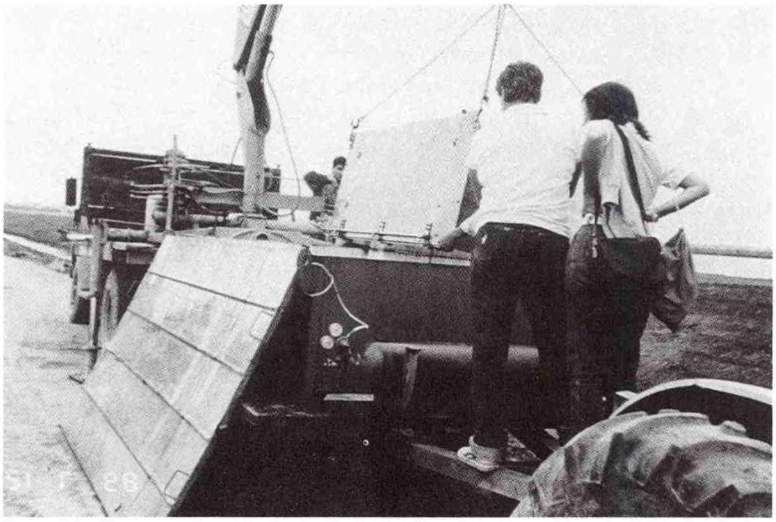

Photo 24.--*Ecuador. Juvenile shrimp collected from a nursery pond are being transported in oxygenated transfer boxes for stocking in growout ponds.* © *Yosuke Hirono*

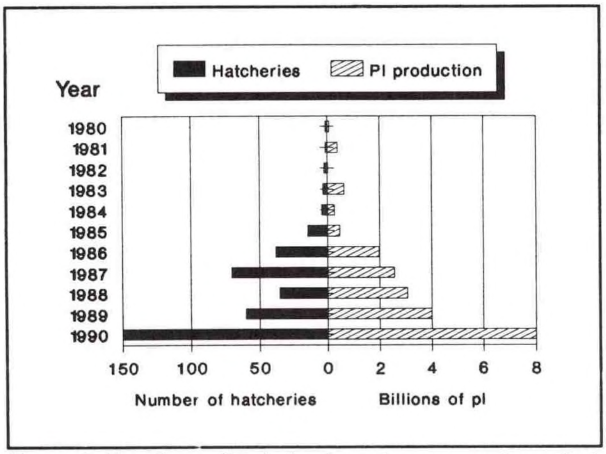

Figure 6.--Ecuador. Hatcheries have become an increasingly important source of postlarvae.

Most Ecuadorean hatcheries are located in Guayas province. While farms are located in the delta along the Gulf of Guayaquil, most hatcheries are located to the west along the Pacific coast. The center of the hatchery industry is "Hatchery Row" near Salinas, and to a lesser extent, Manta. A few hatcheries are also scattered in various other locations along the coast, from Esmeraldas in the north to El Oro in the south. The clustering of hatcheries in a few places has occurred because of the need for pristine, pollution-free water. A few hatcheries have been built at farm sites with less than ideal conditions to reduce losses in transportation and distribution. The performance at these hatcheries, however, has generally not been satisfactory.

Ecuadorean hatcheries vary tremendously in terms of size, technical sophistication, and production capacity--ranging from small backyard units that produce less than 1 million pl per month to highly sophisticated facilities that produce up to 80 million pl per month.[80]

Small hatcheries: Small hatcheries generally utilize basic technology. They produce pl from wild-caught berried females or nauplii purchased from more sophisticated hatcheries. Their chief advantages are low construction and operating costs and the ability to open and close, depending on the season and demand for seedstock.[81] Ecuador's hatchery industry currently seems to be shifting towards the construction of smaller, more manageable hatcheries which produce from 5 to 10 million pl per month.[82]

Large hatcheries: Large hatcheries generally utilize highly technical methods in a controlled environment. Many large hatcheries often report problems with disease, and it often takes them a long time to recover from major production failures.[83] A number of the larger, more sophisticated hatcheries are equipped with broodstock maturation units, which allow hatchery operators to spawn wild broodstock over a period of 3 to 5 months. After this period, broodstock are replaced by fresh animals from the wild.[84]

All of the Ecuadorean hatcheries currently operating are open-cycle facilities, meaning that they are dependent on gravid females which have been captured in the wild (and are the source of the seed used in hatchery maturation).[85] Open-cycle hatcheries, however, have the disadvantage of being subject to the same supply problems encountered by shrimp farmers using wild postlarvae. The supply of gravid females fluctuates depending on climatic conditions and seasonal fluctuations. Wild pl and gravid females are affected by the same climatic fluctuations. As a result, gravid females and wild pl become scarce at the same time. Thus, during an *anti El Niño* event, open-cycle hatcheries are limited in their ability to supply pl--just when their product is most in demand.

Closed-cycle facilities use hatchery produced broodstock (spawned and raised in a hatchery) to produce postlarvae. Ultimately, closed-cycle hatcheries would be able to operate independently--without regard to climatic fluctuations. Several hatcheries have been attempting closed-cycle operations and various groups have made major investments. No Ecuadorean hatchery, however, has successfully carried out long-term closed-cycle runs.[86]

The Ecuadorean hatchery industry has been hampered by several factors, including: a lack of trained **specialists** capable of managing hatchery operations, intermittent **disease** outbreaks, and fluctuations in the **demand** for hatchery pl resulting from changes in the supply and price of wild postlarvae.

Specialists: Hatcheries, especially larger facilities, require a high level of technical expertise. Most of the individuals capable of managing these hatcheries are highly-trained foreign specialists. Many hatchery owners, however, have been reluctant to make the financial commitment needed to attract such personnel. Several companies which had contracted foreign specialists discharged them in 1987 when many hatcheries reported significant losses. The extremely isolated location of most hatcheries also makes it particularly difficult to attract and retain experts, especially foreign specialists.[87] While increasing numbers of Ecuadoreans are acquiring sophisticated training overseas and experience at the domestic hatcheries, adequately staffing the country's large number of hatcheries remains a serious problem.

Disease: Diseases have affected production at Ecuadorean hatcheries, especially the larger facilities. (See Section VII. Disease). The most common hatchery disease, known as *bolitas negras*, has led to high mortality rates in affected sites since 1987. At first, many thought the disease was limited to hatcheries in the Guayas area. Hatcheries in Manabi, however, also reported outbreaks.[88] Observers report that the disease seems to be correlated with water quality changes that affect algae. The disease is aggravated by high bacteria counts, low temperatures, and weak nauplii. Hatchery operators are reporting increased success controlling the disease with large doses of antibiotics and through water filtration.[89]

Demand: The demand for hatchery pl is linked to the supply and price of wild postlarvae. Demand for hatchery pl decreases during periods of wild pl abundance, especially during *El Niño* events. The abundant supply of wild-caught pl during the 1987 *El Niño* was a severe blow to the hatchery industry. The *El Niño* brought unusually large supplies of pl, causing hatchery pl prices to fall below production costs. Many hatcheries, unable to compete with low-cost collectors, had to close down or sharply curtail operations.[90]

Growers generally prefer wild over hatchery pl, asserting that wild pl survives and grows better. Some hatchery operators insist that excellent results can be achieved with hatchery postlarvae. Some scientists speculate that wild pl perform better because they undergo a process of natural selection in the wild before they are collected and thus only the strongest animals have survived. Hatchery pl, on the other hand, are raised in a protected environment and do not undergo the same rigorous selection process. Carefully controlled temperature and nutrient levels and antibiotic application ensure the survivability of many weaker individuals that would not have survived in the harsher, unprotected, wild environment.

Hatchery operators maintain that their pl can perform as well as wild pl, insisting that much of the difference in the number of surviving pl is attributable to the more exact pl counts offered by hatcheries compared to pl purchased from artisanal collectors. Many observers also report that hatcheries have generally improved the quality of their pl and that acceptance by growers appears to be increasing. Hatcheries have reportedly implemented much more rigorous quality control systems. Growers are also becoming more sophisticated in evaluating batches and improving handling techniques.[91] Many growers now dispatch technicians to the hatchery to evaluate large batches before shipment.[92]

Many hatchery operators are reporting increasing success, despite the difficulties. The pl shortage in late 1988, 1989, and early 1990 increased demand for hatchery seedstock and helped revive the hatchery sector. Hatcheries have reported steady production increases and increasing acceptance of their product by growers. Hatcheries face a tenuous economic position, however, as long as growers prefer wild postlarvae. A return of abundant supplies of wild seedstock could dramatically reduce demand for hatchery postlarvae. The 1991-92 *El Niño*, with the resulting abundance of wild pl, could mean that hatchery owners will undergo another consolidation like the one they experienced in 1987. Hatchery pl prices fell sharply in mid-1991 to only $3.40 per 1,000 (appendix H2). Farms with their own hatcheries will probably keep them open, but many of the independent operations may again be forced to close. One observer estimates that a prolonged *El Niño*

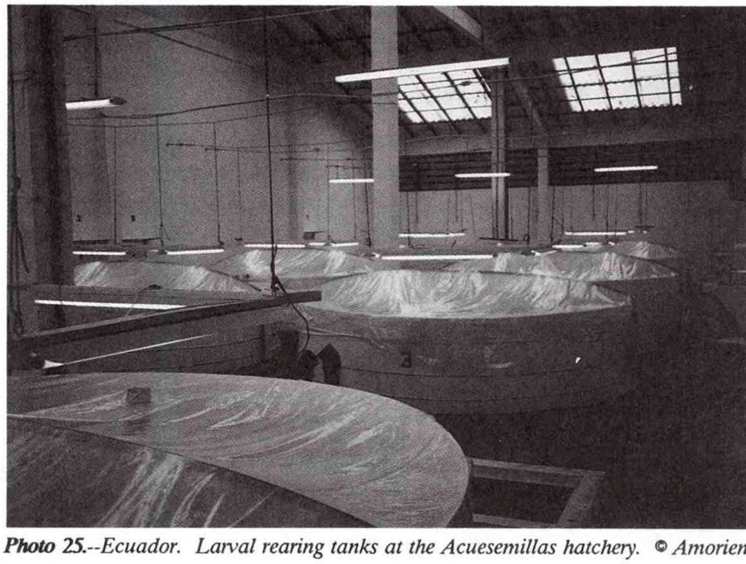

Photo 25.*--Ecuador. Larval rearing tanks at the Acuesemillas hatchery. © Amorient*

would force up to 75 percent of the hatcheries currently operating to close.[93] An *El Niño* occurring in 1993 or 1994 would have a less severe impact, because hatcheries would have more time to establish commercial operations and perfect methods.

Ecuadorean hatchery operators have had one major advantage in that growers were exclusively interested in *P. vannamei*. This enabled the country's hatcheries to focus on one single species, greatly simplifying research. Some countries have had to divide limited research budgets among several different species.[94] Unfortunately, *P. vannamei* has proven to be an especially difficult species to produce in maturation hatcheries.[95]

The Ecuadorean Government, in 1991, authorized the export of hatchery postlarvae for the first time.[96] In January 1991, the Government authorized licenses for the export of hatchery pl to shrimp growers in Andean Pact countries (Bolivia, Colombia, Peru, and Venezuela).[97] The law was amended in August 1991 to allow pl exports to any country.[98] Ecuadorean hatcheries had been prohibited from exporting pl to ensure that the country's growers have an adequate supply of seedstock. An unknown amount of pl, nevertheless, has reportedly always been smuggled out of Ecuador, primarily to Colombian and Peruvian farms.

Ecuador's established hatchery industry may benefit from the increasing demand for pl and nauplii in the region. Access to the rapidly expanding Colombian market could be particularly profitable. Colombian growers until 1991 were supplied primarily by domestic and Panamanian hatcheries.[99] Panamanian hatcheries supply Colombia's Caribbean coast farms. Ecuador is located closer to the Colombian Pacific coast farms at Tumaco. Colombia requires that nauplii/pl shipments be certified disease free, but it is not yet known what Ecuadorean agency will provide such certification. The current situation was complicated when Colombia imposed a ban on the shipment of live organisms in an effort to control the spread of cholera from Peru through Ecuador.[100] Two Ecuadorean hatcheries, Granjas Marinas and Escamarlan, have also begun shipping pl to Honduras, a country experiencing a growing demand for pl but lacking domestic hatcheries.[101]

Many officials and industry groups have criticized the new pl export law, complaining that current Ecuadorean pl supplies are already insufficient. Critics are also concerned that the hatcheries may give preference to foreign customers that pay in U.S. dollars and other hard currencies[102] or raise the domestic price of hatchery postlarvae. They also contend that supplying pl to foreign growers will increase foreign shrimp production, resulting in increased competition in Ecuador's major markets. Hatchery representatives point out that the world shrimp market is so large, that even substantial harvest increases in Colombia, Peru, and other neighboring countries would have only a minimal impact.

The Ecuadorean Government has made some efforts to promote the hatchery industry by providing tax incentives,[103] limited subsidized credit, and by allowing hatcheries to import equipment duty-free. Hatchery operators complain, however, that such Government efforts have been minimal and have had little real impact. They also complain that the application process for the subsidized credits and duty-free import permits is extremely cumbersome. In practical terms, the Ecuadorean Government's ability to assist has been limited by the country's fiscal difficulties.

XII. LEGAL FRAMEWORK

The Subsecretaria de Recursos Pesqueros (SRP), located in Guayaquil, is the Ecuadorean Government body responsible for fisheries. Two administrative dependencies of the SRP--the Dirección General de Pesca (DGP) and the Instituto Nacional de Pesca (INP)--work closely with the aquaculture sector.[104] The Ecuadorean Government's primary mechanism to regulate the aquaculture industry is issuing and revoking of permits. *The Regulation on the Breeding and Culture of Aquatic Species* (Regulation 12771),[105] enacted in 1975, provides a legal framework for regulating the use of intertidal land which is part of the public domain. Prospective shrimp farm operators must obtain a permit from the DGP to legally operate a shrimp pond. (See Section IV. Area). Permits are granted for 10-year periods.[106]

XIII. GOVERNMENT ROLE

The Ecuadorean Government has played only a minor role in the development and promotion of the country's shrimp culture industry. The industry has been almost entirely developed by the private sector with only limited Government assistance. The Government has provided some support, including low interest credit and some technical aid. Many growers complain, however, that the Government aid was too small to have had any real impact and that complicated administrative procedures discouraged participation. This is in direct contrast to several Asian countries (especially China and India),[107] where the governments initiated ambitious export promotion, financing, and technical assistance programs to stimulate and support their developing shrimp culture industries.[108]

Some growers contend that Government policies have on balance actually impeded the industry's development. Many growers complain that the Government discourages investment in the industry through complicated regulations and excessive taxes.[109] Some observers contend that the most serious impact of the Government has been its macroeconomic policies. The strongest complaint has been leveled at exchange rate policies. The Government controls the exchange rate of the Ecuadorean currency, the sucre. Various administrations through most of the 1980s overvalued the sucre. This significantly affects export income. Shrimp growers and other exporters must exchange their foreign currency earnings at exchange rates set by the Government. The exporters receive, however, fewer sucres (at the official inflated rate) per dollar than the free-market rate would justify. Since most shrimp is exported in exchange for dollars and other hard currencies, this significantly reduces profits. In effect, it is a substantial tax on exporters, who pay the difference between the (lower) value in sucres received per dollar and the (higher) real value of shrimp at free-market rates.[110] This has reduced farm income which could have been used to expand and modernize the industry. The Chamber of Shrimp Producers reports that smuggling and other illegal transactions[111] were a serious problem throughout the 1980s, depending on the varying differential between fixed and real exchange rates set by different administrations.[112]

XIV. CREDIT

One of the most serious problems currently facing Ecuadorean shrimp growers is obtaining investment capital. Two factors have contributed to the current credit shortage. First, Ecuadorean interest rates are very high (over 50 percent in January 1991),[113] largely a result of the country's massive foreign debt. Second, the Government has imposed tight restrictions on lending by private sector banks in an effort to control inflation.[114]

Credit is available primarily from two sources--private banks and the Ecuadorean Government.

Private banks: the Government regulates the difference between the interest rates that a private bank can pay depositors and the rate that can be charged borrowers. This difference, in 1989, was 15 percent. Because of these restrictions, banks normally only make extremely conservative loans. Banks continue to evaluate the shrimp culture industry as high-risk. Although some shrimp farmers have been highly successful, a large number of farms have failed. As a result, many shrimp growers are unable to secure loans, either to build new farms or to modernize and expand existing farms. Growers face two problems when applying for loans. First, the banks are concerned with the high risk involved in culturing shrimp. Second, growers have only limited collateral with which to guarantee loans. The assets of a shrimp farm are not easily converted if thegrower defaults. The bank would probably have to find another grower. Banks have reported difficulty selling bankrupt shrimp farms because many were poorly designed or located. As a result, investors are often skeptical about bankrupt farms. Some short-term private credit is available to shrimp growers, but is generally limited to those growers who can provide sufficient collateral. Small and medium sized growers are thus finding themselves frozen out of the credit market.

Government: the second source of credit is subsidized loans funded by the Ecuadorean Central Bank. Such loans have been limited and any major expansion of these credits is unlikely. No data, however, is available to the authors. Generally, the Ecuadorean Government has made only small amounts available to shrimp growers. Some Government officials object to any special credit program for shrimp growers. Successful shrimp growers have realized substantial profits. Government officials complain that a large portion of these profits are deposited in the United States and other foreign countries. The Government believes that restrictive financing for the shrimp growers may force repatriation of profits deposited in foreign bank accounts.[115] At any rate, the country's economic difficulties probably preclude any significant government loan program.

XV. RESEARCH

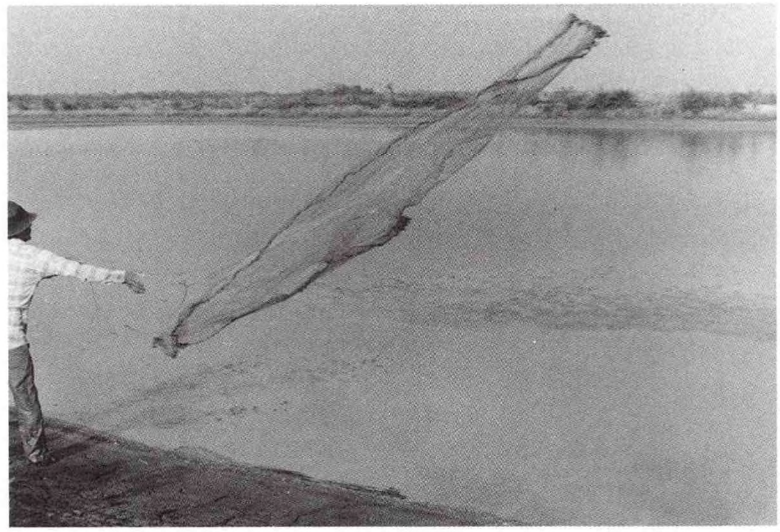

Photo 26.--Ecuador. Some growers have initiated research program to improve pond management. This worker is sampling a pond to assess growth. © *M. Newman, Rangen*

The Ecuadorean Government has only a limited technical capability to assist the industry. The Government has conducted some research and training programs to support the needs of its shrimp culture industry; these programs, however, have been small and played a relatively minor role in the industry's development. Several Latin American countries with much smaller shrimp culture industries (Brazil and Mexico) conduct larger research programs. The Ecuadorean Government fisheries research agency, the INP, has only a small budget, due to the country's fiscal constraints. It has thus been able to devote only a small part of its limited research capabilities to study shrimp. The INP has carried out some projects, including studies on shrimp nutrition, feed, stocking densities, and water quality.[116]

The country has only a few academic institutions which are capable of conducting shrimp culture research. The principal research institutes are the Escuela Superior Politécnica del Litoral (ESPOL), the Instituto Oceanográfico de la Armada (INOCAR), the Centro Nacional de Investigaciones Marinas (CENAIM), the University of Guayaquil (UG), the Catholic University (CU), and the University of Ecuador (UE). The principal academic institution focusing on shrimp culture has been ESPOL, which has reportedly devoted considerable effort to shrimp culture. Other academic institutions have been able to devote only a small part of their research effort to the industry. As a result, published research on shrimp culture has been very limited. This is surprising, given the growth of the industry, its economic importance, and the technical problems it faces.

While Ecuador's research capability is limited, the country clearly has an expanding potential to conduct research. An increasing number of Ecuadoreans have obtained degrees in aquaculture from both Ecuadorean and foreign institutions and in many cases their academic work includes specialized studies on shrimp culture. Growing numbers of Ecuadoreans have amassed increasing experience and sophistication working with the country's expanding aquaculture industry. In addition, the success of important farms has created an industry with very substantial resources capable of supporting a major research effort.

Much of the research conducted in Ecuador has been undertaken by individual companies and has not been published. The quality of this research varies widely. Some of the companies have reportedly conducted effective research programs, enabling substantial improvement in growout and hatchery operations. In other cases, multimillion-dollar growout operations have not carefully collected statistical data to determine even basic management decisions such as optimal stocking densities, growing conditions, feed systems, and other technical matters.

Ecuadorean researchers have worked with a variety of both freshwater and marine species.

Freshwater: Ecuadorean aquaculture researchers have focused primarily on exotic freshwater species, such as shrimp, trout, carp, goldfish, tilapia, and black bass.[117] Most of the freshwater aquaculture research has been conducted by the INP. The authors know of no other Ecuadorean research group which has seriously addressed freshwater shrimp.

Marine: Ecuadorean mariculture research has been directed almost exclusively toward *Penaeid* shrimp, primarily *P. vannamei* and *P. stylirostris*. The authors know, however, of only a few published studies on shrimp culture. The most important research has come from ESPOL, which has conducted both hatchery and growout studies. The INP, CENAIM, UG, CU, and UE have also done some limited work.

Many local and foreign observers are concerned about the limited Ecuadorean research effort. The Ecuadorean shrimp culture industry is one of the most important sectors of the nation's economy. Receipts were over $0.3 billion in 1990 and exceeded $0.4 billion in 1991. Despite this success, the industry still faces many unresolved technical problems and rapidly intensifying foreign competition. The industry as a whole appears to have made little progress in improving yields, unlike many other Latin American and Asian countries. Much of the research which has been conducted in Ecuador has been carried out with the assistance of foreign research groups. Work has been conducted by various U.S. research institutions, especially the University of Rhode Island (URI), Texas A&M University (TAM), and the University of Arizona (UA). Assistance has also come from the European Community (EC) and Japan.

Photo 27.--Ecuador. Processing shrimp at the Humboldt plant. © Sol Barreto, Erin Sales

Available details on the foreign research groups include:

EC: The EC has been a strong supporter of research projects involving shrimp culture. The EC has initiated and helped fund studies of shrimp biochemistry (with ESPOL), shrimp feed (with Penaeid Tecnologia International), polyculture of clams and shrimp (with Sensini), water quality (with ESPOL), and the European seafood market (with the United Nations Food and Agriculture Organization, FAO).[118]

Japan: The Japanese are funding the construction of a $12 million aquaculture center, the Centro Nacional de Acuicultura e Investigaciones (CENAIN) at San Pedro de Manglaralto.[119]

U.S./URI: The URI Coastal Resources Center has conducted an extensive study on coastal zone management, including the impact of pond construction on the estuarine ecosystem.

U.S./TAM: The TAM has done some work on shrimp diseases with ESPOL analyzing bacteria infections.[120] TAM also published a manual written by an Ecuadorean shrimp grower detailing the operating procedures for a semi-intensive shrimp farm.[121]

U.S./UA: The UA and the Chamber of Shrimp Growers are reportedly working on a shrimp pathology laboratory.[122]

XVI. FOREIGN PARTICIPATION

The development of Ecuador's shrimp culture industry has primarily been carried out by local growers and investors. The extensive methods generally adopted by the industry enabled many individuals with limited funding and technical background to initiate operations. Foreign investment and technical assistance, however, have played an important role. Foreign participation has come primarily, but not exclusively, from France, Japan, and the United States. U.S. investment alone possibly exceeds $300 million. Some of the most important U.S. firms with farms and operations in Ecuador include: **Amorient** (See Section IX. Companies), **Baltek** (620 ha semi-intensive farm), **First Republic Corporation** (two semi-intensive farms, 600 ha total), **Empacadora Nacional** (See Section IX. Companies), and **Seaboard**, which has a joint venture with **Continental Grain** (500 ha farm).[123] Companies, financed or managed by foreign owners, control shrimp export companies, shrimp feed and fertilizer manufacturers, many semi-intensive farms, and some of the most successful hatcheries.[124] Ecuadorean law limits foreign ownership to 49 percent, but in many instances legal alternatives are available to foreign investors.[125] Beyond providing investment capital, however, foreign nationals have played an important role in transferring technology,

Photo 28.--Ecuador. A well managed farm is able to deliver an extremely high quality fresh product to nearby packing plants. Dennis Weidner

improving access to sophisticated foreign research. Foreign specialists have played key roles in the more sophisticated semi-intensive farms and the more technically advanced hatcheries. As competition intensifies with growers in other countries, access to foreign technology may become an increasingly important factor.

XVII. PROCESSING

Ecuador has a large number of packing plants to support the shrimp culture industry. The Ecuadorean Government reported in 1988 that there were 75 plants. Most are in Guayas province, although El Oro, Manabi, and Esmeraldas provinces have plants as well. While many firms have obtained the needed authorization, twelve firms dominate the export industry, accounting for more than 60 percent of the country's shrimp exports (appendix I10). Local observers report that the need for working capital, strict quality control to meet international standards, and familiarity with foreign markets is responsible for this concentration in the industry.[126] Many of the packing companies also own and operate farms.

The Ecuadorean Government has taken an active role in maintaining shrimp quality. The DGP and INP issue importation patents and quality control certificates. The INP carries out plant inspections and collects samples of shrimp for testing,[127] and all processors must receive Government authorization to export.[128] The INP has worked closely with the U.S. Government and the FAO in an effort to maintain high quality control standards.[129] The Ecuadorean Government and the U.S. Food and Drug Administration (FDA) initiated a voluntary program for seafood inspection in 1991. Participating Ecuadorean processors will obtain a stamp which will allow expedited entry of their seafood into the United States.

Most exporters pack to U.S. standard product forms. Shrimp exported to the United States is packed frozen and headless in 5-lb boxes. Some companies have begun, however, to diversify their packs. Shrimp destined for Europe is packed whole in 2-kg boxes. Ecuador has also begun to introduce value-added products for export (appendix I7). Various plants peel, devein, and individually quick freeze (IQF) shrimp as a means of obtaining additional revenue.[130] While the production of value-added packs is still limited, such production is increasing.

XVIII. EXPORTS

Ecuador's shrimp culture industry is primarily oriented toward the export market. Ecuadorean exporters shipped $340 million in 1990 (appendix I1).[131] Preliminary data for 1991 suggests that shrimp exports could approach $425 million. The primary market is the United States, but shipments to European countries have increased significantly in recent years (figure 7).

A. United States

The United States is the world's second largest shrimp importing country behind Japan. Although the United States conducts a major shrimp fishery in the Gulf of Mexico and smaller fisheries in the Atlantic and north Pacific, it now imports around 75 percent of its total shrimp supply to meet domestic demand.[132] Most of the U.S. imports are shell-on tails, although some peeled product is also imported (appendix I7).

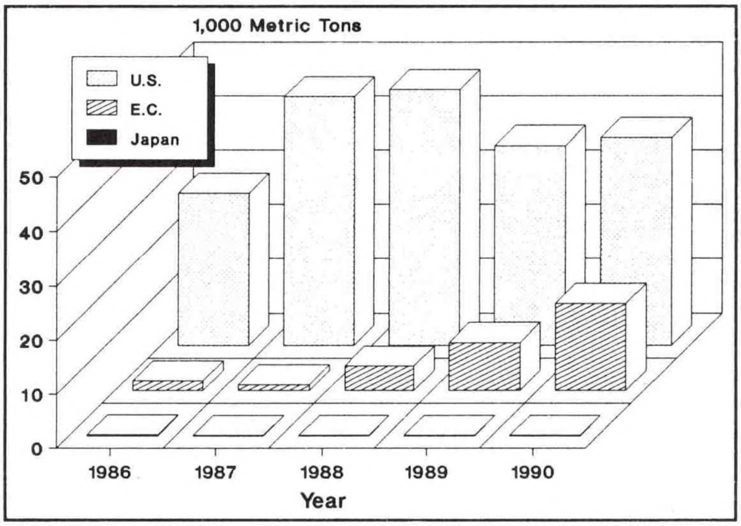

Figure 7.--Ecuador. The United States remains Ecuador's most important export market, but shipments to Europe are growing.

Ecuadorean growers dramatically expanded shipments to the United States in the mid-1980s. Ecuador had several advantages in focusing on the U.S. market. U.S. consumers were already familiar with the white shrimp species growers were culturing and generally considered it to be a premium product.[133] Shipments of Ecuadorean shrimp to the United States totaled 48,800 t in 1991, a 30 percent increase over the 38,300 t shipped in 1990. This made Ecuador the largest supplier of shrimp to the U.S. market (appendix I6).

The increased 1991 shipments are the result of a sharply higher Ecuadorean harvest. A massive decline in Chinese white shrimp exports during 1991 has created especially favorable market conditions for Ecuadorean exports. U.S. companies have had to seek alternate suppliers to replace the declining Chinese deliveries. Ecuadorean growers also face competition from major shrimp culture industries in Southeast Asia producing black tiger shrimp (*P. monodon*). Ecuadorean white shrimp has maintained an image as a higher quality product and thus commands a higher price (appendix F4). Asian black tigers, however, are becoming increasingly familiar to U.S. consumers. Thailand, for example, which produces black tiger shrimp, was the second leading U.S. shrimp supplier in 1991. It is possible that the price differential between Ecuadorean whites and Asian black tigers will narrow during the 1990s.

Ecuadorean growers are optimistic about the possibility of expanding export sales in the 1990s. Total U.S. 1991 shrimp imports were 8 percent higher than in 1990, reversing a downward trend. (U.S. shrimp imports had declined in 1989 and 1990.) U.S. consumption in 1991 might have been higher if the United States was not in the midst of a recession.[134] Shrimp in the United States is primarily consumed in restaurants, and U.S. consumers normally eat out less during recession periods. Many analysts project an increase in U.S. shrimp consumption during the 1990s, especially if real shrimp prices continue to decline.

B. European Community

Through most of the 1980s, Ecuador, like most Latin American growers, shipped little shrimp to Europe. While Ecuador continues to export most of its shrimp to the United States, exporters have achieved considerable success in developing new European markets (appendix I8). Ecuadorean exporters have increased shipments to the EC from less than 200 t in 1986 to over 16,000 t in 1990 (figure 7). European shipments exceeded over 30 percent of Ecuador's total exports in 1990 (appendix I4). Ecuadorean exporters have been especially successful in opening the Spanish and French markets (figure 8). Shipments to Spain, which comprises over two-thirds of Ecuador's European market, were 11,400 t in 1990, nearly a 70 percent increase over 1989 shipments of 6,800 t (appendix I8).[135] Shipments to France rose in 1990 to 3,000 t, a 135 percent increase over 1989 shipments of 1,300

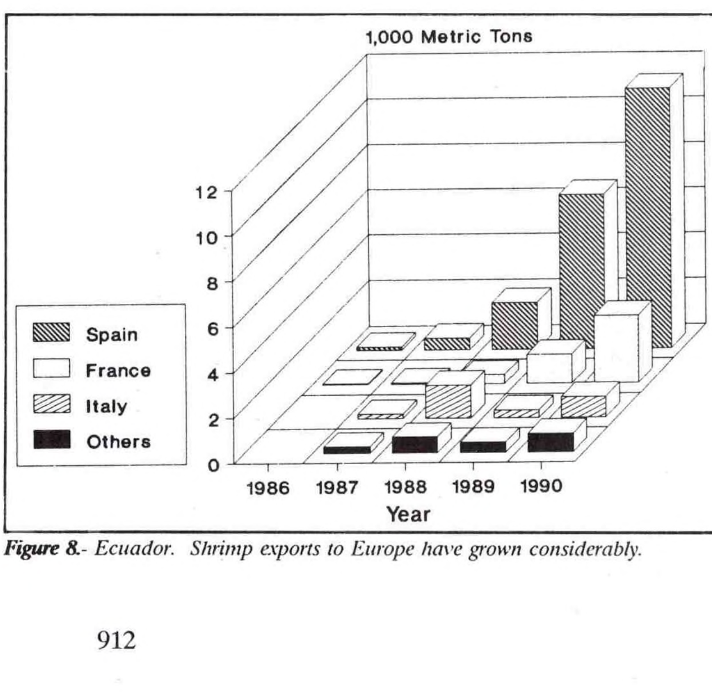

Figure 8.- Ecuador. Shrimp exports to Europe have grown considerably.

tons. It appears that this trend will continue. Shipments of Ecuadorean shrimp to France were 2,200 t through June 1991, nearly a 60 percent increase over the 1,400 t shipped during the same period of 1990.[136] Only a negligible amount of Ecuadorean shrimp is shipped to the large United Kingdom market, probably because British consumers are unwilling to pay a premium for the Ecuadorean product, preferring less expensive Indian and Pakistani shrimp.[137]

Most of the Ecuadorean shipments to Europe are whole shrimp. Industry sources report, however, that harvesting and processing whole shrimp is more difficult than producing frozen tails.[138] Whole shrimp spoils more easily and therefore requires stricter quality controls. Even so, many observers believe that these shipments provide important benefits by permitting exporters to diversify and reduce their dependence on the U.S. market.

The EC decision to eliminate tariffs on shrimp from Ecuador and other Andean countries is aiding Ecuadorean exporters.[139] Many processors, nevertheless, who have for years packed to U.S. standards, are still hesitant to make needed changes in machinery and processing procedures to more fully take advantage of opportunities in the EC market.[140] Industry sources are particularly concerned about European sanitary standards, especially regulations limiting the use of preservatives. Growers and processors insist that preservatives must be used to maintain quality standards of heads-on shrimp. Some European countries, however, have strict standards concerning the use of chemical preservatives. The problem is frustrating packers who would like to expand shipments to Europe.[141]

While the European market is currently the smallest of the three major world markets (appendix I2), some observers believe that European consumption could increase significantly in the 1990s. Germany currently consumes only small quantities of shrimp; rising German income levels, however, are beginning to affect consumption patterns, and this could result in increased demand for shrimp. Another large market, Italy, imports only small quantities of Ecuadorean shrimp (appendix I8). In addition, the emergence of market economies in Eastern Europe will eventually offer significant additional opportunities.

C. Japan

Japan is the world's leading shrimp importer (appendix I2), relying on foreign sources for 90 percent of its supply. Japan consumes more shrimp per capita than in the United States or Europe. Japanese shrimp consumption--led by an increase in world shrimp production, a booming Japanese economy, and a strong yen--increased 50 percent between 1980-88. Most Japanese shrimp imports (over 80 percent) are supplied by Asian/Pacific countries, especially China, Indonesia, India, Thailand, Taiwan, Vietnam, and the Philippines.[142] Ecuadorean shrimp exports to Japan, however, have been negligible (appendix I9).

Two factors may explain Ecuador's limited shipments to Japan. First, Ecuadorean shrimp may be priced too high for the Japanese market. Ecuadorean cultured white shrimp is more expensive than Chinese cultured white shrimp.[143] Japanese consumers may be unwilling to pay the premium price for Ecuadorean shrimp that growers can command in the U.S. and European markets. The Japanese market for white shrimp is quite large--over 43,000 t in 1990. Almost all of that amount, however, is supplied by China. Second, Ecuador's limited shipments to Japan may be also be influenced by established trading patterns.[144] As the Ecuadorean shift to European markets demonstrates, however, such trading patterns can be altered.

XIX. ECONOMIC IMPACT

The shrimp culture industry makes a major contribution to the Ecuadorean economy. The value of Ecuadorean shrimp exports in 1990 -- $340 million -- was the third highest valued export behind petroleum and bananas.[145] Preliminary results suggest that 1991 shrimp exports could approach $430 million, exceeding bananas. Throughout the 1980s, earnings from the shrimp industry have supplied much-needed foreign currency.

The shrimp culture industry also plays an important social role by significantly contributing to employment in isolated coastal areas. Around 140,000 people are directly employed in shrimp culture industry as artisanal pl collectors,[146] shrimp farm and hatchery workers and technicians, and processing plant employees. Another 15,000 people are involved in indirect support industries producing

Photo 29.--Ecuador. Wild pl collection is often a family business. © *Lee Lippert, Lippert International*

feed, fertilizer, paper, plastic, and heavy equipment; other spin-off industries include construction, transportation, insurance, security, and consultants.[147] One consultant estimates that 500,000 Ecuadoreans depend on the income generated by the country's shrimp farming industry.[148]

XX. OUTLOOK

The outlook for the Ecuadorean shrimp culture industry appears promising, although some problems limit the more optimistic projections. The country's excellent growing conditions, large number of successful farms, rising harvests, increasing expertise, strong market acceptance in the United States, and expanding penetration into the European market have created optimism in industry circles. Considerable progress has been made in resolving one of the industry's principal problems--postlarval seedstock supplies. The potential clearly exists for the industry to continue its expansion, though it is unlikely that the rate of growth will match that of the 1980s. Some observers, however, express caution, especially over the failure of many growers to improve methods. Other problems include increasing pollution and disease outbreaks and the industry's minimal support for research programs.

Harvest increases during the 1980s were primarily due to a steady expansion of pond area. If pond area does not continue to increase in the 1990s, and it appears that it will not, growers will have to improve methods to achieve further harvest increases. Ecuadorean growers continue to report lower average yields than many competitors in Asia and Latin America. Some observers insist that low yield, low cost operations may be the best alternative for the country's growers. Other observers are convinced, however, that Ecuador will have to improve methods and increase yields if it is to remain competitive with major foreign producers.

Several factors will determine the degree to which Ecuadorean growers will be able to intensify their operations and improve yields during the 1990s. The most important are:

Investment capital: Growers may have difficulty securing the capital necessary to carry out pond improvements because of the country's restricted credit markets. Credit is difficult to obtain and available only at exceedingly high interest rates.

Profit margins: A shift to more intensive methods would require major capital investments. Many growers report increasing operating costs due to higher feed, fuel, labor, and seedstock prices. At the same time, the real price of shrimp has decreased substantially. This is reducing earnings (and the growers' ability to re-invest in their operations).

Research: There is a need for more extensive research. Despite the fact that shrimp culture is one the country's leading economic sectors, only a small commitment is currently being made to carry out research. A shift to more sophisticated, semi-intensive methods will require more knowledge about feed, stocking densities, hatchery maturation, and other subjects. Shrimp pathology is one subject which should be studied extensively. Some growers have reported disease problems, and higher stocking densities are likely to lead to increasingly serious outbreaks.

Trained personnel: The industry's continued expansion will create a significant demand for trained hatchery and growout personnel. Ecuador's current in-country programs produce increasing numbers of technicians, but are not producing a sufficient number of specialists with the advanced skills necessary to meet the industry's demanding technical problems.

Future industry trends are unclear. Some observers report progress in increasing yields. Others insist that most growers have made little progress, and that the higher 1991 harvests were due to higher stocking densities resulting from the unusually widespread availability of postlarval seedstock. If growers succeed in making even minor improvements in pond management and yields, Ecuador could achieve substantial harvest increases during the 1990s. It is likely that some improvement will occur, and growers should be able to achieve a harvest of at least 150,000 tons by the year 2000. If growers are able to overcome major problems, substantially larger harvests are possible.

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ENDNOTES

SECTION I (Capture Fishery)

1. A good description of the capture fish industry is available in Charles McPadden, Jaime Barragán, y Carlos Rodríguez, "Un Estudio de la Pesqueria del Camarón en el Ecuador," in *Boletín Científico y Tecnico*, Vol IX, No. 4, Instituto Nacional de Pesca, 1988. For details on specific species see Section III. Species.

SECTION II (Growing Conditions)

2. The Guayas River Basin, the largest area suitable for pond construction in Latin America, is located in southern Ecuador.

3. Bob Rosenberry, *Shrimp Farming in the Western Hemisphere*, June 1990.

4. U.S. Consulate General, Guayaquil, June 11, 1990.

5. Farm raised *P. vannamei* grow well in water temperatures of 25° C or above, but growth slows when temperatures fall to 23° C or below. Some Ecuadorean farmers reported morning pond temperatures as low as 20° C in 1989. Rosenberry, *Shrimp Farming in the Western Hemisphere*, *op. cit.*

6. A study of the fishing trawl fleet during 1986 and 1987 by the Instituto Nacional de Pesca suggests that the wild shrimp stock increased during the *El Niño* event. For more information see McPadden, Barragán, and Rodríguez, *op. cit.*

7. Hatchery pl sold for as much as $25 per 1,000 in 1985; in contrast, it sold for only $4.40 per 1,000 in mid-1987 during an *El Niño* year. Dennis Weidner, "Latin American Shrimp Culture, 1986-90," *International Fishery Report* (IFR-88/40), May 13, 1988.

8. One good review of pollution levels from various sources is available in Jairo J. Escobar Ramirez and Uwe Barg, "La Contaminación de las Aguas Continentales de Bolivia, Colombia, Costa Rica, Ecuador, Panama, Peru y Venezuela," COPESCAL *Documento Tecnico*, FAO, 1990.

9. *El Universo*, February 16, 1990. These reports suggested the problem was reaching crisis levels. Press reports on such topics, however, are often highly sensationalized.

10. Phil Boeing, Sensini, personal communications, March 30, 1990. An Ecuadorean Government official expressed some concern over pollution, but does not see it as a major problem at this time. Luis Torres, Dirección General de Pesca, personal communications, September 26, 1990.

11. U.S. Embassy, Quito, November 5, 1991.

12. Yosuke Hirono, Penaeid Tecnologia Internacional (PENTEC), personal communications, March 4, 1991.

13. Dave Larson, Cargill, personal communications, June 27, 1991.

14. For a review of the effects of mangrove deforestation, see R.R. Twilley, University of Southwestern Louisiana, "Ecosystem Analysis of Mangroves and Shrimp Mariculture in Ecuador," presented at the American Association for the Advancement of Science meeting, 1990. Also see E.J. Lahman, S.C. Snedaker, and M.S. Brown, "Structural Comparisons of Mangrove Forests Near Shrimp Ponds in Southern Ecuador," Rosenstiel School of Marine and Atmospheric Science, University of Miami, 1987.

15. Some observers report that the preferred sites for shrimp ponds are salt flats devoid of vegetation, but few of these sites remain. This has led many shrimp growers to clear mangroves to build additional pond area. John Clark, editor, "Coastal Resource Management: Development Case Studies," U.S. National Park Service, March 1985. In many cases, a careful pond design could have preserved mangrove areas without significantly reducing the area of ponds constructed.

16. Regulation 12771 (1975), amended by Regulation 14425 (1989), prohibits the destruction of mangrove areas. Anne Houtte, Nicola Bonucci and William Edeson, "A Preliminary Review of Selected Legislation Governing Aquaculture," *Aquaculture Development and Coordination Programme*, FAO, Rome 1989.

17. Torres, personal communications, *op. cit.*

18. Chamber of Shrimp Producers, *White Book of Shrimp*, May 1989.

SECTION III (Species)

19. Carolina Solórzano and Iván Saballos, *La Industria del Camarón en Ecuador: En Busca de una Nueva Estrategia*, report prepared for Instituto Centroamericano de Administración de Empresas (INCAE), August 1989.

20. Neil Baxter, NMFS, Galveston Texas, personal communications, May 21, 1991. Also see S. Corvest "Ecuador-Peru: *Penaeus vannamei* rearing, Analysis of some growth results." *Aquaculture Review*, February 1989.

21. One of the leading U.S. research groups has been the Shrimp Mariculture Project at Texas A&M University.

22. Robin Rackowe, International Marine Fisheries Company, personal communications, April 30, 1990.

23. McPadden, Barragán, and Rodríguez, *op. cit.*

24. The Southeast Asian Fisheries Development Center (SEAFDEC) has published an excellent survey on *P. monodon* culture. SEAFDEC, *Biology and Culture of Penaeus Monodon*, 1988.

25. Paul Niemeier and Mark Wildman, "Chinese Shrimp Culture," *International Fishery Report* (IFR-91-43), June 14, 1991.

26. Phil Boeing, Sensini, personal communications, August 1, 1990.

SECTION IV (Area)

27. In addition to environmental concerns, new shrimp sites require a certificate from the Ministry of Tourism declaring that they will not be constructed on areas set aside for tourism or public bathing; a certificate from the municipality is also required declaring that the site will not be constructed in an urban or residential area. *El Universo*, March 1, 1991.

28. Calculating the pond area actually being utilized is further complicated by the fact that some ponds have been built without Government authorizations.

29. Subsecretaria de Recursos Pesqueros.

30. Chamber of Shrimp Producers, *op. cit.*

31. One report states that many pond sites in El Oro are abandoned due to financial difficulties. See F. Doumenge, "Aquaculture in Ecuador," in *Aquaculture*, Vol. 1 & 2 (1989), Technique et Documentation-Lavoisier, Paris.

SECTION V (Harvests)

32. Rosenberry, *Shrimp Farming in the Western Hemisphere, op. cit.* and Weidner, "Latin American Shrimp Culture Industry, 1986-90" *op. cit.*

33. Jose Medina, SEPESCA, "La camaronicultura en Ecuador," *Boletín de Acuacultura*, February 1991.

34. Medina, *op. cit.*

35. *El Universo*, March 29, 1991.

36. Timely Ecuadorean harvest data is not available to the authors. U.S. import data is a good, albeit imperfect, indicator of harvest trends.

37. Yosuke Hirono, PENTEC, personal communications, July 18, 1991.

38. Dave Aiken, "Shrimp Farming in Ecuador," *World Aquaculture*, September 1990.

SECTION VI (Methods/Yields)

39. Yosuke Hirono and Sjef van Eys, "The Ecuadorean Shrimp Culture Industry," *INFOFISH INTERNATIONAL*, April 1990.

40. Dennis Weidner, Tom Revord, and Randolf Wells, "Latin American Shrimp Culture, 1990-2000" *International Fishery Report*, in press.

41. The Chamber of Shrimp Producers divide the farms into three categories: extensive, semi-extensive, and semi-intensive. Semi-extensive farms, by their definition, use pumps and feeds at some stages of the maturation process and have average annual yields of about 0.8 t per hectare. All that distinguishes them from the semi-intensive farms is a slightly lower use of feeds and other technology. Many analysts would include them in the semi-intensive category, as the authors have done here. The 1.0 t per ha average yield figure given in the text is a weighted average of the semi-extensive and semi-intensive yield provided by the Chamber of Shrimp Producers.

42. Aiken, *op. cit.*

43. Intensive farms are especially prone to disease problems. This is reportedly due to the stress on the animals resulting from the high stocking densities, which makes them more susceptible to disease. Diseases can also spread quickly in the elevated stocking densities at the farms. This potentially serious problem was demonstrated by Taiwan's intensive shrimp culture industry, which experienced massive disease mortalities in the late 1980s. Dr. Martin Maffa and Callender McDowell, "Water Quality Vital to Farm Success," in *Fish Farming International*, July 1991.

44. Bob Rosenberry, *World Shrimp Farming 1990*. In contrast to Ecuador, Indonesia still has a large amount of coastal land available to convert to shrimp ponds.

45. For details see Weidner, Revord, and Wells, *op. cit.*

46. Many farms in neighboring Colombia and Peru, for example, are reporting yields of 2-4 t per ha or more. Dennis Weidner and Tom Revord, "Colombia Shrimp Culture," *International Fishery Report* (IFR-91/90), December 15, 1991. Tom Revord and Dennis Weidner, "Peruvian Shrimp Culture," *International Fishery Report* (IFR-91/91), December 6, 1991. Dennis Weidner and Tom Revord, "Guatemalan Shrimp Culture," *International Fishery Report* (IFR-91/92), December 20, 1991. Dennis Weidner, "Honduran Shrimp Culture," *International Fishery Report* (IFR-91/21), March 29, 1991.

47. Hirono, PENTEC, personal communications, July 18, 1991.

48. Phil Boeing, Sensini, personal communications, August 12, 1991.

49. Alexander Ewing, Escuela Superior Politécnica del Litoral (ESPOL), letter to *AQUABYTE*, Vol. 4, No. 2, 1991.

SECTION VII (Disease)

50. Todd Schneider and David Decker, "Taiwan Shrimp Culture" *International Fishery Report* (IFR-91/66), August 16, 1991.

SECTION VIII (Production Costs)

51. Johnie Castro, Editor, *Notilarva*, personal communications, October 16, 1991. Other observers cite a higher cost of $4.43 per kilogram. Solórzano and Saballos, *op. cit.* (appendix G4).

52. The Ecuadorean advantage is even greater because most Asian countries produce black tiger shrimp, which has a lower price on the U.S. market than Ecuador's white shrimp (appendix F4).

53. For details see Niemeier and Wildman, *op. cit.*

54. Solórzano and Saballos, *op. cit.*

SECTION IX (Companies)

55. Phil Meyer, Amorient, personal communications, January 31, 1992.

56. Alfonso Delfini, General Manager, Aquamar, personal communications, February 13, 1992.

57. Gilberto Escobar, President, Cosemar, personal communications, February 3, 1992.

58. Javier Leon, Ecuamar, personal communications, February 4, 1992.

59. Walter Valarezo, El Rosario, personal communications, February 10, 1992.

60. Flavio Yannuzzelli, Empacadora Nacional, personal communications, July 10, 1991.

61. Fernando Alvarez, General Manager, Lagoscorp, personal communications, February 3, 1992.

62. L.F. Anderson, Ecuadminsa, personal communications, February 1, 1992.

63. Cesar Estupiñan, General Manager, Estar, C.A., personal communications, July 11, 1991.

64. *Aquaculture Digest*, May 1986.

65. Castro, *op. cit.*

SECTION X (Feed)

66. Hirono and van Eys, *op. cit.* Ecuadorean production of fishmeal (an important ingredient in shrimp feed) has declined since 1985, largely the result of a declining catch of mackerel and other small pelagic species. Fish meal production in 1989 was only 73,530 t (less than 10 percent of 1985 levels). Most of the 1989 product was exported, primarily to Japan and Colombia; only 2,500 t of meal was available for domestic feed production. Imports of fishmeal into Ecuador are currently prohibited. Reportedly, a large amount of fishmeal is smuggled

into Ecuador from Peru to meet the demand of the Ecuadorean shrimp feed industry. U.S. Embassy, Quito, March 9, 1990.

67. Hirono and van Eys, *op. cit.* Feed cost between $0.28-0.42 per kilogram in 1991, depending on protein content (20-40 percent). Castro, *op. cit.*

68. One report suggests that 25 percent of the nutrients applied as fertilizers are wasted (washed away). Alexander Ewing, "The Aquatic Environment - its effect on fisheries and aquaculture in Ecuador," *EC Fisheries Cooperation Bulletin*, March 1991.

69. The Ecuadorean Government has banned the importation of binders which would improve feed stability and decrease feed disintegration. Rosenberry, "Shrimp Farming in the Western Hemisphere," *op. cit.*

70. For further details see: Centro Nacional de Investigaciones Marinas (CENAIM) "The Basic Nutritional Requirements of *P. vannamei* for the Larval and Juvenile Stages" and Edgar Arellano, Luis Gomez, and Mabel Yaguachi, "Preliminary maturation diet preparation and evaluation for *P. vannamei* broodstock, Ecuador," ESPOL.

71. Yosuke Hirono, "Ecuadorian Shrimp Culture Industry," presented at Shrimp World IV, November 1989.

SECTION XI (Postlarval Seedstock Supplies)

72. Estimates vary, but around 13 billion pl are probably needed annually to stock Ecuador's 104,000 ha of shrimp ponds. Roy Buddle, "Ecuador's Shrimp Hatcheries Aim for Top Quality," *Fish Farmer*, May 1990.

73. Paul Maugle, PDM & Associates, personal communications, May 22, 1991.

74. Chua Thia-Eng, quoted in *World Shrimp Farming*, November 1990.

75. Hirono and van Eys, *op. cit.*

76. For details on the early development of Ecuador's shrimp hatcheries, see Dennis Weidner, "Ecuadorean Shrimp Hatcheries," *International Fishery Report* (IFR-85/03B), January 30, 1985.

77. Weidner, "Latin American Shrimp Culture, 1986-90," *op. cit.* The number of hatcheries operating is usually less than the number authorized; for example, the Government authorized the construction of 105 hatcheries in 1989, but only 60 were operational. Solórzano and Saballos, *op. cit.* Hirono and Van Eys, *op. cit.*

78. *Fish Farming International*, May 1991. Observers report varied estimates on the number of hatcheries. This is probably due to the fact that Ecuador has a large number of small, basic operations that only operate seasonally.

79. Roy Buddle, Sanofi Aquaculture, personal communications, July 31, 1991.

80. Buddle, "Ecuador's Shrimp Hatcheries Aim for Top Quality," *op. cit.*

81. Rosenberry, *World Shrimp Farming 1990, op. cit.*

82. Buddle, personal communications, *op. cit.*

83. Bob Rosenberry, *World Shrimp Farming 1991.*

84. Many hatcheries with maturation units report technical problems. One observer reports that at any given time, however, only 12 to 18 of the hatcheries with broodstock maturation units are operating. Buddle, personal communications, *op. cit.*

85. Buddle, personal communications, *op. cit.*

86. Buddle, personal communications, *op. cit.* Closed-cycle maturation techniques require great technical sophistication and highly qualified management. A very limited number of individuals worldwide during the 1980s were qualified to operate such facilities.

87. Sophisticated maturation hatcheries require constant, 24-hour monitoring. Inexperienced biologists might be willing to work brief periods at isolated locations. Experienced hatchery managers, however, would generally find the personal living conditions (not to mention accommodations for their families) unacceptable. For details see Weidner, "Ecuadorean Shrimp Hatcheries," *op. cit.*

88. Buddle, personal communications, *op. cit.*

89. Phil Boeing, Sensini S.A., "Disease strikes hatcheries in Guayas, Ecuador," in *World Shrimp Farming*, May 1990. Some observers have expressed concern over the widespread use and high dosage levels of antibiotics in Ecuador.

90. Weidner, "Latin American Shrimp Culture, 1986-90," *op. cit.* and Chamber of Shrimp Producers, *op. cit.* One observer reports that only 10 hatcheries were operational in 1987. Solórzano and Saballos, *op. cit.*

91. R. Barbieri, "Reception and Nursery Pond Management of Penaeus Vannamei: a Strategy to Improve Production and Increase Survival," *Artemia Newsletter*, March 1990.

92. Maugle, *op. cit.*

93. Buddle, personal communications, *op. cit.*

94. Brazilian growers have yet to agree on the preferred species to use; as a result, hatcheries have had to work with a wide variety of species. Dennis Weidner, "Brazilian Shrimp Culture Industry" *International Fishery Report*, (IFR/90-92) December 21, 1990.

95. Phil Boeing, "Hatchery Differences in the Culture of *P. vannamei, P. stylirostris*, and *P. monodon*," as reprinted in *Aquaculture Digest*, February 1987.

96. According to the Official Register, only pl produced under "el proceso de maduración" can be legally exported. The authors have been unable to determine the exact meaning of this criteria. It is most likely that it refers to pl produced in hatcheries equipped with broodstock maturation units.

97. Acuerdo No. 665. *Registro Oficial No. 599*, January 9, 1991.

98. Acuerdo No. 354. *Registro Oficial No. 763*, September 5, 1991.

99. Dennis Weidner and Tom Revord, "Panamanian Shrimp Culture," *International Fishery Report* (IFR-92/94), December 27, 1991.

100. Weidner and Revord, "Colombian Shrimp Culture," *op. cit.* Full details are not available, but Ecuadorean hatcheries reportedly increased shipments of hatchery pl to Colombia in 1991. Some Panamanian hatcheries may have been affected by the increased competition.

101. "Ecuador Venderá Larvas de Camarón a Honduras," *Telegrafo*, September 17, 1991 and Weidner, "Honduran Shrimp Culture," *op. cit.*

102. Luis Herreria, former Undersecretary for Fisheries and currently a legal advisor to fishing industry groups, personal communications, April 3, 1991.

103. Aiken, *op. cit.*

SECTION XII (Legal Framework)

104. Ramiro Vásquez, Minister of Commercial Affairs, Embassy of Ecuador, personal communications, September 11, 1991.

105. Houtte, Bonucci and Edeson, *op. cit.*

106. Growers pay an annual fee of 300,000 sucres for each ha authorized (1989 report). Houtte, Bonucci, and Edeson, *op. cit.*

SECTION XIII (Government Role)

107. For more details see Todd Schneider, "India Shrimp Culture," *International Fishery Report* (IFR-91/18), March 14, 1991. Also see Niemeier and Wildman, "Chinese Shrimp Culture," *op. cit.*

108. The Ecuadorean Government has made some credits available, but they have amounted to a small part of overall investment. (See Section XIV. Credit).

109. Sjef van Eys, "Shopping for Fish and Seafood in Latin America Can be Rewarding," *Quick Frozen Foods International*, April 1991.

110. Chamber of Shrimp Producers, *op. cit.* and Eduardo Egas, Chamber of Shrimp Producers, unpublished report on exchange rate policies, 1990.

111. Ecuadorean officials have continually reported significant differences between exports reported by growers and imports reported by destination countries. Much of this is probably due to under-reporting by growers.

112. An unknown quantity of cultured shrimp has been smuggled between Ecuador and Peru for reexport. The exchange rate, tax policies, and export subsidies in the two countries determines the direction and rate of this activity. The Chamber of Shrimp Producers estimates that the value of the shrimp smuggled to Peru for reexport exceeded $9 million in 1988. Smuggling has also occurred from Peru to Ecuador. The Peruvian Government and the Central Reserve Bank, in August 1990, however, established a single exchange market for foreign currency transactions, based on free market dollar rates. This has eliminated the motivation for Peruvians to smuggle, but could increase Ecuadorean shrimp smuggling through Peru. Chamber of Shrimp producers, *op. cit.* and *Chile Pesquero*, February 1989. *Telivisión Peruana*, August 10, 1990. The Ecuadorean Government has attempted to control false invoicing (which is used to avoid currency laws) by requiring that exporters obtain a provisional export license which is valid for only 15 days. U.S. Embassy, Quito, November 5, 1991.

SECTION XIV (Credit)

113. *Análisis Camaronero*, February 1991.

114. "Economic Trends Report," U.S. Embassy, Quito, December 1, 1990.

115. U.S. Embassy, Quito, March 9, 1990.

SECTION XV (Research)

116. Walter Andrade, Subsecretario de Recursos Pesqueros, Dirección General de Pesca, personal communications, October 25, 1991. Some observers question the capability of Government institutions to conduct important research programs. Public institutions generally offer low salaries, leading many shrimp specialists to seek employment with private companies.

117. "Estado Actual de la Acuicultura en el Ecuador," in *Informes de Pesca* (La Acuicultura en America Latina, Vol 3 Informes Nacionales), No. 159.

118. Eduardo Egas, Federación Ecuatoriana de Exportadores de Camarón, (FEDECAM), personal communications, October 11, 1991; "Misión de CE evalua planes pesqueros, *El Universo*, March 5, 1991 and Ewing, *op. cit.*

119. U.S. Embassy, Quito, November 5, 1991.

120. "Comprueban bacterias en larvas de camarón," *Telegrafo*, August 8, 1990.

121. See José Villalón, "Practical Manual for Semi-Intensive Commercial Production of Marine Shrimp," published by Texas A&M University Sea Grant Program, College Station, Texas.

122. Boeing, personal communications, March 30, 1990.

SECTION XVI (Foreign Participation)

123. Raul Ramiro, Seaboard, personal communications, September 26, 1991.

124. Weidner, "Latin American Shrimp Culture Industry, 1986-90" *op. cit.* and Bob Rosenberry, Editor/Publisher, *World Shrimp Farming*, personal communications, June 13, 1990.

125. Unconfirmed reports indicate that the Government has significantly relaxed its enforcement of the law requiring majority Ecuadorean ownership. The statutory limitations, however, remain in effect.

SECTION XVII (Processing)

126. The Government enforces an export marketing system that restricts the ability of small farms with limited quality control standards to export. For further information on the minimum requirements that Ecuadorean shrimp processing plants must meet, see I. Goulding, "Un Código de Prácticas Recomendadas para el Procesamiento de Camarón," Instituto Nacional de la Pesca, 1988.

127. Andrade, *op. cit.*

128. Vasquez, *op. cit.*

129. Andrade, *op. cit.*

130. Hirono, "The Ecuadorean Shrimp Culture Industry" *op. cit.*

SECTION XVIII (Exports)

131. Over 90 percent of Ecuador's total shrimp production was comprised of cultured shrimp in 1990.

132. U.S. Department of Commerce, *Fisheries of the United States 1990,* May 1991.

133. Ecuadorean white shrimp commands a higher price than Chinese white shrimp because of its higher and more consistent quality (appendix F2).

134. Charles Peckham, "Shrimp: Bargain Buys Coming to an End," *Seafood International*, October 1991.

135. *Análisis Camaronero*, February 1991 and *El Universo*, January 17, 1991.

136. Ecuador has overtaken Senegal as France's largest supplier of shrimp. Observers report that the high quality and relatively low price of Ecuadorean shrimp explain its success. FAO *Globefish Highlights*, September 1991.

137. FAO *Globefish Highlights*, March 1991. British shrimp demand is also partially affected by traditional trading patterns with the Commonwealth countries as well as the consumption patterns of the large Pakistani and Indian ethnic communities.

138. Gilberto Escobar, Cosemar, in *World Shrimp Farming*, March 1991.

139. The EC has eliminated tariffs for several Andean countries to support anti-drug programs. *INFOPESCA Noticias Comerciales*, February 20, 1991.

140. Most exporters continue to ship primarily to the United States, but some companies are shipping as much as half of their product to Europe. Karen Straus, "Expect More Farmed Shrimp in the Future," *National Fisherman Yearbook*, 1991.

141. Herreria, *op. cit.*

142. Ousa Sananikone, *The Shrimp Industry: Global Subsector Study*, The World Bank Industry and Energy Department, December 1989.

143. Ron Boren, Ocean Gardens Seafood, personal communications, May 14, 1991. Ecuadorean shrimp commands a higher price compared to Chinese shrimp because of better processing standards and packaging. Freight costs from Ecuador to Japan might also contribute to the high price of Ecuadorean shrimp. Charles Peckham, Editor, *LMR Shrimp Market Report*, personal communications, May 10, 1991.

144. Rosenberry, personal communications, May 13, 1991.

SECTION XIX (Economic Impact)

145. *Telegrafo*, January 17 and March 29, 1991.

146. During periods of pl abundance, the fishery provides a major source of employment for generally depressed rural areas.

147. Chamber of Shrimp Producers, *op. cit.* Federación Ecuatoriana de Exportadores de Camarón (FEDECAM), "Análisis de la Situación del Sector Exportación Camaronero."

148. Ewing, "The Aquatic Environment--its effect on fisheries and aquaculture in Ecuador," *op. cit.*

APPENDICES

Appendix A.--Addresses.

TELEPHONE CODES:

Ecuador country code (593)
Guayaquil (4)
Cuenca (7)

Government Agency

Embasssy of Ecuador
Commercial Office
2535 15th St, NW
Washington, DC 20009; USA
Telephone: 202/667-2194
FAX: 202/265-9325

Ministerio de Industrias, Comercio, e Integracion
V.M. Rendon 1006-1010
Casilla 8356
Guayaquil, Ecuador
Telephone: 308413

Promotion Groups

Camara de Productores de Camaron, CPC
Tungurahua 519 y 9 de Octubre
Edificio Santa Martha
Guayaquil, Ecuador
Telephone: 371242

Federacion Ecuatoriana de Exportadores de Camaron
FEDECAM
Av. 9 de Octubre 1911
Edificio Finansur
Piso 13, Oficina 1302
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Appendix B.--Ecuador. Shrimp species.

Species		
Scientific	English*	Spanish*
Marine		
Penaeus	Penaeids	Penidios
brevirostris	Crystal	Cristal/rojo
californiensis	Yellow leg	Patiamarillo/café
occidentalis	Western white	Blanco del Pacifico/blanco
stylirostris	Blue	Azul/blanco
vannamei	Whiteleg	Patiblanco/blanco
Solenocera		
agassizi	Kolibri	Chupaflor/rojo
florea	Flower	Picaflor/rojo
Trachypenaeus		
byrdi	Carabali	Carabalí/tigre
faoe	Indio	Fijador indio/cebra
pacificus	Zebra	Cebra/tigre
Xiphopenaeus riveti	Pacific seabob	Botalón/tití
Protrachypene precipua	Titi	Titi/pomada
Freshwater		
Macrobrachium	River Prawn	Agua Dulce
americanum	Cauque	Cauque

* FAO terms, commonly used Ecuadorean names after slash in Spanish column.
Source: FAO. "Shrimps and Prawns of the World" FAO Species Catalogue, Vol. I, Rome, 1980.

Appendix C.--South America. Sea surface temperatures, 1989-91.

Year/ Month	Pacific			Atlantic	
	Northern Peru	Southern Ecuador	Colombia	Colombia	Northeast Brazil
			Degrees Celsius		
1989					
January	21	23	26	27	27
February	23	24	24	26	27
March	23	25	26-28	27	26
April	23	25	27	27	26
May	19	21	26-27	28	27-28
June	20	24	26-27	27-28	27
July	20	22	26-27	28	27-28
August	19	23	26-28	29	26-27
September	18	22	26-28	29	27
October	19	23	26-28	29	27
November	19	22	26-27	28	27-28
December	21	25	26-27	28	27
1990					
January	22	25	26-27	27	27
February	22	25	26	26-27	27
March	23	26	27-29	26-27	27
April	21	24	26-27	26-27	27
May	22	25	27-28	28-29	28
June	21	24	27-28	28-29	27
July	20	24	26-28	28-29	27
August	20	25	25-28	28	25-27
September	21	25	25-28	29	25-27
October	19	22	25-27	28	26-27
November	20	22	25-28	28	26-27
December	21	22	26-27	27	27
1991					
January	23	24	26-27	27-28	27
February	25	26	26	26-27	27
March	24	25	27	27	27-28
April	23	24-25	27-28	27-28	28-29
May	22	24	27-28	27	28
June	21	25	27-28	27-29	27-28
July	20	24	27-28	27-28	26-27
August	20	24	27-28	27-28	26-27
September	19	23	26-27	28	25-26
October	20	25	26-28	28	26-27
November	20	25	27	28	27
December	21	24	27	27	27

Note: Temperatures are approximations based on visual estimates from map graphics.
Source: Climate Analysis Center. National Weather Service, NOAA. TOGA Analysis.

Appendix D1.--Ecuador. Shrimp farm pond area, 1976-90.

Year	Concessions		Actual
	Annual	Accumulated	Utilization
	Hectares		
1976	439	439	316
1977	1,906	2,345	1,690
1978	1,833	4,178	3,011
1979	2,767	6,945	5,005
1980	7,762	14,707	10,599
1981	20,385	35,092	25,291
1982	13,186	48,278	34,794
1983	13,969	62,247	44,861
1984	24,199	86,446	62,302
1985	16,041	102,487	73,862
1986	19,012	121,499	87,564
1987	7,475	128,974	92,952
1988	9,780	138,754	100,000
1989	4,648	143,402	104,000
1990	NA	NA	110,000E
Total	NA	126,017*	NA

E - Estimate
* The Ecuadorean Government revoked concessions for 17,385 ha of ponds between 1976-89.
Source: Direción General de Pesca.

Appendix D2.--Ecuador. Shrimp concessions and authorizations, by province, 1987.

Province	Ponds	
	Authorizations	Share
	Hectares	Percent
Guayas	81,247	71.1
El Oro	20,702	18.1
Manabi	8,828	7.7
Esmeraldas	3,428	3.0
Total	114,205	100.0

Source: The Chamber of Shrimp Producers, The White Book of Shrimp, May 1989.

Appendix D3.--Ecuador. Mangrove and shrimp pond area,* 1969-87.

Category	Year		
	1969	1984	1987
	Hectares		
Mangroves	203,624	182,157	170,056
Shrimp Ponds	-	89,075	113,530

* Pond authorizations
Source: Chamber of Shrimp Producers, The White Book of Shrimp, May 1989.

Appendix E1.--Ecuador. Total shrimp production, wild-caught and cultured, 1979-91.

Year	Production			Share
	Capture	Culture	Total	Cultured
	1,000 Metric Tons*			Percent
1979	7.8	4.7	12.4	37.6
1980	7.8	9.2	17.0	53.9
1981	8.0	12.1	20.1	60.3
1982	8.0	21.5	29.4	72.9
1983	8.9	35.7	44.6	80.1
1984	6.3	33.6	39.9	84.2
1985	6.0	30.2	36.2	83.4
1986	9.2	43.6	52.8	82.6
1987	9.6	69.2	78.2	88.3
1988	10.8	70.1	80.9	86.7
1989	6.2	64.2	70.4	91.3
1990	6.9E	70.0E	76.9E	91.0E
1991	7.5P	100.0P	107.5P	93.0P

E-Estimated
P-Projected
* Liveweight equivalent
Note: Ecuadorean Government harvest figures may be low. The Chamber of Shrimp Producers reports that smuggling was a serious problem in 1988 and early 1989 because of Ecuador's overvalued exchange rate. This would make actual production figures higher.
Source: Direccion General de Pesca.

Appendix E2.--World. Estimated cultured shrimp harvests and yields by major countries and regions, by harvest, 1988-90.

Country/Region	Harvest			Yields
	1988	1989	1990	
	1,000 Metric Tons*			Tons/Ha/Year
China	100	165	150	1.0
Indonesia	50	90	120	0.4
Thailand	40	90	110	1.8
Ecuador	**70**	**60**	**70**	**0.7**
India	30	25	32	0.5
Taiwan	50	20	30	3.8
Philippines	30	50	30	0.6
Vietnam	20	30	30	0.2
Other	40	30	34	NA
Latin America**	15	20	24	0.8
Total	445	580	625	0.6***

NA - Not available
* Liveweight equivalent
** Other than Ecuador
*** Average
Sources: Bob Rosenberry, World Shrimp Farming (Asian data).
Various country sources (Latin American data).

Appendix E3.--World. Estimated cultured shrimp harvests and yields by major countries and regions, by yield, 1988-90.

Country/Region	Harvest 1988	1989	1990	Yields
	1,000 Metric Tons*			Tons/Ha/Year
Taiwan	50	20	30	3.8
Thailand	40	90	110	1.8
China	100	165	150	1.0
Latin America**	15	20	24	0.8
Ecuador	**70**	**60**	**70**	**0.7**
Philippines	30	50	30	0.6
India	30	25	32	0.5
Indonesia	50	90	120	0.4
Vietnam	20	30	30	0.2
Other	40	30	34	NA
Total	445	580	625	0.6***

NA - Not available
* Liveweight equivalent
** Other than Ecuador
*** Average
Sources: Bob Rosenberry, World Shrimp Farming (Asian data).
Various country sources (Latin American data).

Appendix E4.--World. Marine shrimp production, 1982-91.

Year	Production Trawler	Culture	Total	Share Cultured
	1,000 Metric Tons*			Percent
1982	1,652	84	1,736	5
1983	1,683	143	1,826	8
1984	1,733	174	1,907	9
1985	1,908	213	2,121	10
1986	1,910	309	2,219	14
1987	1,881	483	2,364	20
1988	2,073	445	2,518	18
1989	1,863	580	2,443	24
1990	NA	635	NA	NA
1991	NA	690	NA	NA

NA - Not available
* Liveweight equivalent
Sources: FISHDAB, FAO Fisheries Department. Bob Rosenberry, World Shrimp Farming.

Appendix E5.--Latin America. Cultured shrimp harvests, 1985-91.

Country	Year						
	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	6.0E	9.8P
Mexico	0.1	0.2	0.8	2.4	3.2	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	2.6E	3.0E	2.8E	3.5E	3.5E	3.5E	2.7P
Brazil	0.8	0.9	1.0	1.4	2.0	2.5E	2.5P
Guatemala	0.5	0.6	0.8	0.8	0.8	1.1E	2.4P
Others	0.8	1.0	1.0	1.6	1.8E	1.5E	2.0P
Total	40.0	52.2	80.5	88.5	86.6	101.0E	139.9P

E - Estimated
P - Projected
* Liveweight equivalent
Sources: Various country sources.

Appendix E6.--Latin America. Ecuadorean share of regional cultured harvest, 1985-91.

Year	Pond Harvest		Total	Ecuadorean share
	Ecuador	Other		
	1,000 Metric tons*			Percent
1985	30.2	9.8	40.0	76
1986	43.6	8.6	52.2	84
1987	69.2	11.3	80.5	86
1988	70.1	18.4	88.5	79
1989	64.2	22.4	86.6	74
1990	70.0E	31.0E	101.0E	69E
1991	100.0P	39.7P	139.7P	72P

E - Estimated
P - Projected
* Liveweight equivalent
Sources: Various country sources.

Appendix F1.--Ecuador. Wholesale prices of frozen, headless, shell-on Ecuadorean white shrimp at New York, 1980-91, by size.*

Year	Count							
	Under 16	16-20	21-25	26-30	31-35	36-40	41-50	51 +
	US$/kg							
1980	NA	NA	11.27	10.34	9.08	8.25	NA	NA
1981	NA	NA	12.06	9.90	8.33	7.69	NA	NA
1982	NA	NA	14.35	13.34	11.95	10.87	NA	NA
1983	16.69	16.18	15.59	12.99	12.02	11.29	10.23	8.55
1984	18.72	16.58	14.09	11.71	10.43	8.93	8.25	7.85
1985	16.95	14.24	11.97	10.60	9.08	8.66	8.09	7.12
1986	16.47	15.65	14.68	13.01	11.46	10.52	9.66	8.13
1987	20.11	17.70	14.20	11.62	9.50	8.36	7.83	7.50
1988	20.66	18.14	16.47	12.90	10.56	8.64	7.43	6.35
1989	20.09	16.32	12.91	11.12	9.84	8.71	8.31	6.67
1990	15.68	14.46	13.64	11.96	10.12	8.82	7.69	6.71
1991	18.99	16.22	13.59	11.53	9.66	8.39	7.73	6.00

* Tails per pound
Sources: NMFS Fishery Market News Report (1980-88). Charles Peckham, LMR Shrimp Market Report (1989-91).

Appendix F2.--Ecuador. Wholesale prices of frozen, headless, shell-on 31-40 count* Ecuadorean white shrimp at New York, 1980-91.

Year	Price
	US$/kg
1980	8.66
1981	8.01
1982	11.41
1983	11.65
1984	9.68
1985	8.87
1986	10.99
1987	8.93
1988	9.60
1989	9.28
1990	9.47
1991	9.03

* Tails per pound
Note: The price for 31-40 count shrimp presented here is an unweighted average of the price of 31-35 and 36-40 count shrimp.
Sources: NMFS Fishery Market News Report (1980-88). Charles Peckham, LMR Shrimp Market Report (1989-91).

Appendix F3.--Ecuador. Wholesale prices of frozen, headless, shell-on 31-40 count* Ecuadorean white shrimp at New York in constant 1980 dollars, 1980-91.

Year	Price
	US$/kg
1980	8.66
1981	7.18
1982	9.46
1983	9.22
1984	7.15
1985	6.15
1986	7.36
1987	5.54
1988	5.42
1989	4.59
1990	3.92
1991	3.13

*Tails per pound
Note: The price for 31-40 count shrimp presented here is an unweighted average of the price of 31-35 and 36-40 count shrimp. Price deflator - CPI-U, 1980=100.
Sources: NMFS Fishery Market News Report (1980-88). Charles Peckham, LMR Shrimp Market Report (1989-91).

Appendix F4.--United States. Shrimp prices (31-40 count), May 3, 1991.

Country/type	Price	Primary source
	US$/lb	
Whites		
US (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 G1.--Ecuador. Primary marine shrimp farms, by harvest, 1991.

Company	Ponds	System	Harvest
	Hectares*		Tons**
Quirola Group	6,500	E	6,000♦
El Rosario	3,100	E/SI	5,000
Morrison Group	1,000	SI/I	3,300
Vannoni Group	2,000	E/SI	1,400♦
AmOrient Group	500	SI/I	1,200
Aquamar	500	SI	1,100
Ecuamar	800	SI	1,000
Lagoscorp	640	SI	1,000
Empacadora Nacional	870	SI	800♦
Langostino Group	700	SI	630♦
Perez Group	650	SI	590♦

* Utilized
** Liveweight equivalent
♦ 1990 data
Key: E - extensive; SI - semi-intensive; I - intensive
Sources: Yosuke Hirono, Sanofi Aquaculture, personal communications, March 27, 1991 and individual farms.

Appendix G2.--Ecuador. Farms by yield and culture method, 1987.

Method	Pond Area	Pond Harvest	Pond Yield
	Hectares	Metric Tons	Tons per Hectare
Extensive	60,000	25,000	0.4
Semi-extensive*	25,000	20,800	0.8
Semi-intensive	15,000	23,100	1.5**
Total	100,000	68,900***	0.7

* The Chamber of shrimp producers define semi-extensive farms as those that use pumps and feeds at some stages of the maturation process, but not to the same extent as semi-intensive farms. All that distinguishes them from the semi-intensive farms is a slightly lower use of feeds and other technology. Most definitions would include them in the semi-intensive category, as the authors did in the text.
** Yields for the semi-extensive and semi-intensive farms combined would be about 1.1 t per hectare.
*** Liveweight equivalent
Source: Chamber of Shrimp Producers, The White Book of Shrimp, May 1989.

Appendix G3.--Ecuador. Shrimp farms, by size, 1988.

Farms: Size	Farms: Number	Share
Hectares	Number	Percent
1 - 50	867	61
51 - 100	213	15
101 - 150	114	8
151 - 200	100	7
201 - 250	85	6
251+	43	3
Total	1,422	100

Source: Dirección General de Pesca. Printed in Solórzano and Saballos, "La Industria del Camaron en Ecuador: En Busca de una Nueva Estrategia," August 1989.

Appendix G4.--Ecuador. Production costs for shrimp farmers, July 1989.

Item	Production Costs	
	Sucres/lb	US$/kg
Direct costs		
Pl	285	1.20
Feeds	250	1.05*
Indirect costs		
Salaries, fuel water, etc.	80	0.34
Depreciation	320	1.35
Financing costs		
Interest payments	115	0.49
Total costs	1,050	4.43
Revenue	1,280	5.40
Costs minus revenue	230	0.97
Profit margin (percent)	22	22

*Feeds are normally the most important cost item for shrimp farms, but in July 1989 pl prices reached a peak of $13 per thousand pl because the Government imposed a closed season on shrimp fishing and wild pl collection. Model based on 36-40 count shrimp at an exchange rate of 521.38 sucres per dollar.
Source: Solorzano and Saballos, "La Industria del Camaron en Ecuador: En Busca de una Nueva Estrategia," August 1989.

Appendix H1.--Ecuador. Operating Hatcheries and production of P. vannamei, 1980-1990.

Year	Hatcheries Number	Production
	Number	Million pl
1980	1	83
1981	1	405
1982	2	34
1983	3	652
1984	4	280
1985	14	488
1986	38	1,979
1987	70	2,566
1988	35	3,080
1989	60	4,000
1990	150	8,000

Sources: Hirono and Leslie, 1989 (1980-89). Roy Buddle, Fish Farming International, May 1991 (1990).

Appendix H2.--Ecuador. Postlarvae prices, wild and hatchery, 1989-91, mid-year.*

Year	Postlarvae Wild	Hatchery
	US$ per 1,000	
1989	9.05	8.11
1990	8.02	4.39
1991	5.53	3.40

* Average June price.
Sources: Notilarva, July 1989 (1989). Análisis Camaronero, August 1990 (1990). Yosuke Hirono, Sanofi Aquaculture, personal communications, July 18, 1991 (1991).

Appendix I1.--Ecuador. Total shrimp exports, wild-caught and cultured, by volume and dollar value, 1980-1990.

Year	Exports Quantity	Value
	1,000 Metric Tons	US$ Million
1980	9.6	66.2
1981	12.1	63.9
1982	17.0	129.7
1983	23.6	185.7
1984	19.1	146.7
1985	20.0	156.0
1986	31.1	287.9
1987	48.7	383.1
1988	56.2	387.0
1989	46.3	328.2
1990	52.8	340.3

Source: Dirección General de Pesca.

Appendix I2.--World. Shrimp imports by the United States, Japan, and the European Community, 1982-90.

Country/Region	Year								
	1982	1983	1984	1985	1986	1987	1988	1989	1990
	1,000 Metric Tons								
Japan	151	149	169	183	213	246	261	263	283
United States	124	155	155	163	182	217	229	228	227
European Community*	101	110	119	124	145	156	190	172	188

* European Community imports refer only to Extra-EC imports, not Intra-EC imports.
Sources: US Census Bureau (U.S. import data); Japan Marine Products Importers Association, Japan Tariff

Association, and LMR Shrimp Market Report (Japan import data); and FAO, The European Shrimp Market: Coldwater
versus Warmwater and EC Nimexe (EC import data).

Appendix I3.--Ecuador. Shrimp exports by country, 1986-90.

Year	Country			Total
	US	EC	Japan	
	1,000 Metric tons			
1986	28.1	0.2	0.2	30.3
1987	45.9	1.1	0.1	47.1
1988	47.1	4.6	0.1	51.8
1989	36.8	8.9	0.1	45.8
1990	38.3	16.1	Negl.	54.4

Negl. - Negligable
Note: Slight discrepancy between total and appendix I1 due to rounding and other variables.
Sources: US Department of Commerce, Bureau of the Census.
EC Nimexe. Japan Tariff Association.

Appendix I4.--Ecuador. Exports to the United States, Europe, and Japan by share of total exports, 1988-90.

Country/Region	Year		
	1988	1989	1990
	Percent		
United States	80.0	89.0	67.0
Europe	18.6	9.2	31.0
Japan	0.2	0.3	Negl.
Other	1.0	1.0	2.0
Total	100.0	100.0	100.0

Negl. - Negligable
Source: Estadisticas de Importacion y Exportacion Cit. Ltda, in Analisis Camaronero, February 1991.

Appendix I5.--Ecuador Monthly shrimp exports to the United States, by quantity, 1986-91.

Month	1986	1987	1988	1989	1990	1991
			1000 Metric Tons			
January	1.0	1.7	3.0	2.7	2.3	2.6
February	0.9	2.9	3.8	2.5	2.1	3.1
March	2.0	3.1	4.6	3.9	3.1	3.9
April	1.8	3.6	3.3	2.6	2.8	4.0
May	2.5	3.9	4.3	3.4	3.7	4.0
June	3.0	5.0	4.3	3.7	3.3	4.3
July	2.8	4.4	4.6	4.1	3.4	4.7
August	2.5	4.2	4.0	3.5	4.0	5.2
September	3.0	4.3	4.1	3.0	3.8	5.0
October	2.7	4.1	3.7	2.9	3.2	4.1
November	3.1	3.7	3.1	2.4	3.2	3.7
December	3.0	5.0	4.3	2.1	3.4	4.1
Total*	28.1	45.9	47.1	36.8	38.3	48.8

* Totals may not agree due to rounding.
Source: US Department of Commerce. Bureau of the Census.

Appendix I6.--United States. Shrimp imports from major countries 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	10.7	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	10.8	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
Indonesia	2.1	0.4	0.5	0.7	0.9	0.9	1.0	1.7	2.0	6.1	8.6	11.5
Philippines	0.3	0.2	0.3	0.6	1.1	2.1	2.1	2.5	3.4	6.4	4.7	6.4
Honduras	2.1	2.8	3.0	3.2	2.4	2.3	2.5	3.3	4.1	3.4	4.2	5.9
Panama	6.2	7.2	8.0	7.4	7.4	8.9	9.9	7.5	6.7	7.8	5.3	5.9
Pakistan	1.5	2.0	2.4	3.1	4.9	5.1	6.5	8.0	6.6	4.4	5.5	5.3
Bangladesh	0.4	0.9	1.5	1.6	1.5	1.9	2.8	4.2	5.3	5.9	6.7	4.9
Colombia	1.5	1.3	1.3	1.3	1.6	1.5	2.0	2.0	1.9	2.7	3.7	4.6
Brazil	4.0	4.9	5.8	6.6	9.0	11.5	9.0	7.5	9.0	7.6	4.0	3.8
Singapore	0.2	0.2	0.5	0.7	1.3	1.5	2.6	3.2	2.5	3.6	3.1	3.6
Malaysia	0.9	0.6	0.1	0.6	0.5	1.1	1.9	2.0	2.8	3.6	3.4	3.5
Venezuela	1.8	0.7	0.9	1.0	2.3	3.0	4.1	2.7	4.0	5.6	3.5	3.5
Canada	1.1	1.1	1.7	2.0	1.3	1.9	1.6	3.1	2.4	1.9	2.2	3.4
Guyana	2.4	1.1	1.9	1.9	1.6	1.1	2.3	2.1	2.1	2.2	2.1	2.8
Guatemala	1.6	2.0	2.0	1.5	2.0	1.7	1.3	1.5	1.9	2.8	2.5	2.2
Peru	0.7	0.9	1.3	4.3	3.0	2.0	1.7	2.7	1.9	1.8	2.2	2.2
El Salvador	2.8	3.0	3.3	2.1	3.9	2.8	3.4	3.3	3.7	2.8	2.4	2.1
Taiwan	2.5	2.5	4.2	9.0	8.3	13.4	15.7	16.8	7.9	3.4	1.6	1.4
Others	13.4	12.0	15.7	22.1	23.8	25.0	17.9	14.9	11.6	10.2	9.6	8.3
Total	99.5	101.0	124.2	154.8	155.3	163.2	181.5	216.9	228.5	228.1	227.4	244.8

Source: US Department of Commerce. Bureau of the Census.

Appendix I7.--Ecuador. US shrimp imports by size count, 1991.

Product/ Size	Imports	
	Quantity	Value
	Metric tons	US$ Million
Shell-on		
under 15	9,868.2	88.5
15/20	1,736.7	12.3
21/25	1,025.9	8.8
26/30	2,433.1	18.8
31/40	7,777.0	58.6
41/50	5,824.9	39.7
51/60	3,376.3	20.7
61/70	1,610.9	9.3
over 70	1,707.1	8.4
Peeled	11,647.7	84.0
Other*	1,826.1	13.5
Total	48,833.9	362.6

* Includes fresh, dried, and salted shell-on and peeled shrimp.
Source: US Department of Commerce. Bureau of the Census.

Appendix I8.--European Community. Shrimp imports from Ecuador, by importing country, 1986-90.

Country	Year				
	1986	1987	1988	1989	1990
			Metric tons		
Spain	143	507	2,062	6,789	11,433
France	40	62	402	1,268	2,959
Italy	Negl.	195	1,464	353	907
Other	Negl.	287	693	446	811
Total	184	1,051	4,621	8,856	16,110

Negl. - Negligable, less than 25 metric tons.
NA - Not available
Source: EC NIMEXE.

Appendix I9.--Japan. Shrimp imports from Ecuador, 1982-90.

Year	Quantity
	1000 Metric tons
1982	0.4
1983	1.0
1984	0.7
1985	0.4
1986	0.2
1987	0.1
1988	0.1
1989	0.1
1990	Negl.

Negl. - Negligable
Source: Japan Tariff Association.

Appendix I10.--Ecuador. Shrimp export companies, by value of exports, 1988.

Firms		Exports		
Value range	Number	Quantity	Value	Share
US$ Million		Metric Tons	Million US$	Percent
10.0 to 35.0	12	31,450	238.7	61
5.0 to 10.0	10	8,320	68.1	17
1.0 to 5.0	26	9,048	71.5	18
0.5 to 1.0	10	1,298	8.0	2
0.1 to 0.5	10	525	2.7	1
0 to 0.1	16	116	0.5	Negl.
Totals	84	50,757	389.5	100

Negl. - Negligable
Source: Chamber of Shrimp Producers, The White Book of Shrimp, May 1989.

Appendix I11.--Ecuador. Eight largest shrimp export companies, by quantity and dollar value of exports, 1990.

	Exports	
Company	Quantity	Value
	1,000 Metric Tons	US$1,000
Exporklore	6.0	35,650
Exportad/Expalsa	4.7	28,800
El Rosario	4.6	26,350
Granmar	3.2	17,070
Empacadora Nacional	2.6	20,810
Promariscos	2.5	15,940
Pesquera St. Priscila	2.2	11,560
Oceanpac	1.9	13,980

Source: Federacion Ecuatoriana de Exportadores de Camaron (FEDECAM).

4.7

FRENCH GUIANA

The future of the French Guiana shrimp culture industry is unclear. Growers have demonstrated the technical ability to culture freshwater shrimp. They harvested a record 89 tons in 1989, although the 1990 harvest declined slightly. A few farms have closed since 1987, but the remaining farms have improved growout methods and yields. The commercial viability of a major freshwater shrimp culture industry in French Guiana, however, remains to be demonstrated. The industry appears viable in countries (Brazil, Dominican Republic, Guadeloupe, and Martinique) where there is a strong local market. The success of an industry in a country like French Guiana which would have to be based primarily on export shipments, however, remains in question. Low meat yields relative to marine shrimp, relatively high production costs, and the lack of consumer familiarity with the species currently restrict sales. As a result, French Guiana growers have experienced marketing problems. Current worldwide trends suggest that the expanding harvest of cultured shrimp worldwide may result in increasing pressure on shrimp prices. As a result, French Guiana growers may find a very difficult market environment during the 1990s. Sales of fresh product as a gourmet dish may allow the growers to successfully compete, but their ability to significantly expand export shipments has not yet been demonstrated.

CONTENTS

I. BACKGROUND

French Guiana was made an Overseas Department (OD) of France in 1946 and an administrative region in 1974. It is thus neither a colony or independent country, but an administrative unit (OD) of France. The OD has a small population of 115,000 inhabitants, much of which is centered in the capital, Cayenne (map 1).

II. CAPTURE FISHERY

The shrimp fishery is virtually the only fishery of importance in French Guiana.

Map 1.--*Map of French Guiana.*

Commercial: The shrimp fishery is French Guiana's only significant commercial fishery. It was initiated by foreign fishermen who have conducted a shrimp trawl fishery on the Guianas Banks since the 1950s with vessels based in Cayenne. Foreign fishermen, primarily U.S. and Japanese, have dominated the fishery. French fisherman are now playing an increasingly important role. In recent years, the French Government has been gradually phasing out licenses to foreign fishermen as French nationals expand their fleet and increase their catch (appendix A).[1] Fishermen used to fish extensively off Brazil where catch rates were apparently higher, but Brazilian enforcement activity has reduced such effort. **Artisanal**: Artisanal fishing is more limited in French Guiana than in neighboring countries. France supports the local economy, keeping wages high. As a result, the relatively low earnings available from artisanal fishing are not attractive. The fleet registered by the Government in the early 1980s consisted of about 50 canoes and a number of larger vessel. A substantial number of such vessels are reportedly unregistered. More recent data is unavailable. The fishermen use the vessels to set gill nets and stake seines. Other fishermen deploy a small number of Chinese seines which are usually set in the estuaries at the mouths of rivers. The catch is primarily finfish, but some shrimp is also taken.

The overall shrimp catch varies substantially from year to year. French-flag fishermen reported a 1989 catch of nearly 3,000 metric tons (t), a 20 percent increase over the 2,500 t taken in 1988 (appendix A).[2] As a result of the small local population, almost all of the catch is exported.

III. AQUACULTURE

Little progress has been made in developing an aquaculture industry in French Guiana. The authors known of no commercial aquaculture operations except for freshwater shrimp.

IV. CLIMATE

French Guiana's climate is subtropical with temperatures averaging about 26°C throughout the year. Annual rainfall averages more than 250 centimeters. The rainy season extends from December through June.

V. SPECIES

The capture shrimp fishery is based on various marine species, primarily *Penaeus brasiliensis* and *P. subtilis*. No marine shrimp culture projects, however, currently exist in French Guiana. The French Government helped finance studies on one indigenous species of brown shrimp (*P. subtilis*) in the late 1970s. The studies, conducted in estuaries near St. Laurens, were discontinued after 2 years. The French concluded that the species was unsuitable for pond culture. Some observers are convinced, however, that marine shrimp can be cultured in French Guiana. Private groups have assessed various sites[3], but none has yet decided to build a marine shrimp farm. One unconfirmed report suggests that a freshwater shrimp farm, the Polder Mari-Anne operation, that had to close in 1987, is reportedly being redesigned to permit the culture of marine shrimp.[4]

French Guiana growers have chosen to work primarily with freshwater shrimp. They have selected an exotic species, *Macrobrachium rosenbergii*. The authors have no information on efforts to assess indigenous freshwater shrimp species. Growers in other Latin American countries, however, have generally reported difficulties working with indigenous species and almost uniformly have turned to *M. rosenbergii*.

VI. INITIAL EFFORTS

Local government authorities in French Guiana expressed an interest in a shrimp aquaculture industry during the 1970s. As part of the Regional Development Program, officials initiated the "Green Plan" in 1976 which included provision for promoting an aquaculture industry to supply both domestic and export markets.[5] The State Secretariat and the Institut Francais pour la Recherche et l'Exploitation de la Mer's (IFREMER) France-Aquaculture group, began experimenting with freshwater shrimp culture in French Guiana during 1979. Officials initially projected an industry with 200 hectares (ha) of ponds which could supply 500 t of shrimp per year to export markets.

The project was conducted by **Guyane -Aquaculture** (GA), the local IFREMER subsidiary. Unlike the situation on Guadeloupe and Martinique,[6] the industry was introduced as a new economic activity and not as an alternative to a declining wild fishery. The GA project was set up by Jean-Michel Griessinger, one of the Centre National pour l'Exploitation des Oceans (CNEXO)[7] scientists who developed the "clear-water" hatchery technique. GA/IFREMER has played a major role in the development of the industry and continues to offer critical services to growers. GA evaluated the potential, prepared a development plan, and opened a demonstration farm. GA also offers extension services, including site selection, engineering studies, design suggestions, construction evaluations, and training opportunities.[8]

The technical problems associated with founding a new industry, as in the French Caribbean Islands, resulted in program delays and budgetary allocations beyond those initially envisioned.[9] The initial phase of the project consisted of trail runs to assess growout rates and local conditions. The first experimental ponds were stocked in 1979-80 with postlarvae (pl) obtained from Martinique and Florida.[10] Some work had to be done to develop suitable methods for French Guiana conditions.[11] The results proved favorable technically and GA announced a 5-year development program to build 200 ha of ponds. GA built a demonstration farm in 1983 and continues to operate it.

VII. POSTLARVAL SEEDSTOCK

The initial shrimp culture operations in French Guiana relied on imported pl seedstock. GA began building a hatchery in 1982 capable of producing 12 million pl per year and expanded that capacity to 25 million pl by 1987. The hatchery was a regional project, based on a modular design. Pl demand was less than anticipated, however, and production was only about 9 million pl in 1989 and 2 million pl in 1990.[12] The hatchery uses the clear water recirculating system, a high density, closed rearing system (100 larvae per liter) with biofiltration conceived and improved in Tahiti.[13]

VIII. RESEARCH

IFREMER biologists at the Kourou experimental station are studying shrimp culture and attempting to develop techniques to improve pond management.[14] The station has a laboratory for water and soil analysis, nine experimental ponds (ranging from 500-5,000 square meters (m) with a total area of 1.7 ha, and 40 cubic m of concrete nursery tanks. Shrimp culture was reportedly assigned as the station's top priority in 1986. The research is concentrated on practical studies of water control, fertilization, and aeration with a goal of improving farm profitability.[15]

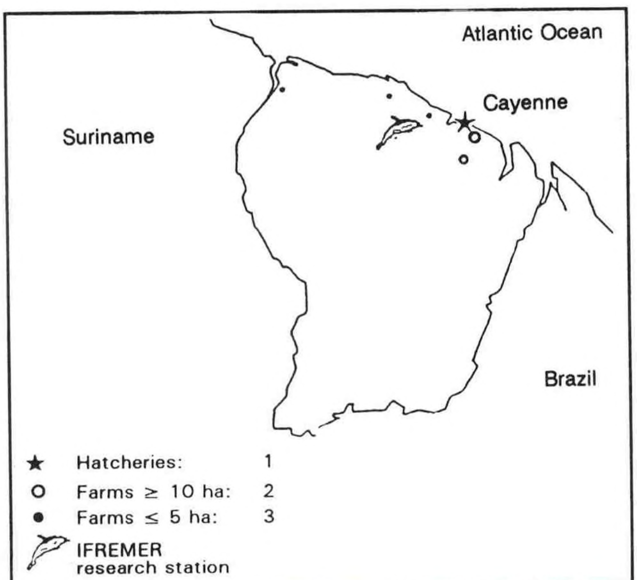
IX. TERRAIN/AREA

French Guiana is located along the northern coast of South America, only a few degrees north of the Equator. The coast has fertile, rolling plains occasionally broken by hills that gradually rise to the Tumac-Humac Mountains along the Brazilian border in the south. Most of the Department is unsettled, covered by the dense tropical rain forest of the Amazonian Basin. The Department's area is much larger than the two insular French Caribbean territories (Guadeloupe and Martinique) and totals about 90,000 square kilometers.

The shrimp culture industry in French Guiana currently utilizes only a small fraction of available sites. Unlike the French Caribbean Islands, considerable unused land is potentially available in French Guiana if shrimp culture proves profitable. Much of this land is virgin forest and not currently being used for any economic activity. As a result, freshwater growers would not have difficulty locating additional sites for expansion. One report suggested that farmers hoped to have completed 120 ha of ponds by 1988[16]; however, that goal was not met. About 73 ha of ponds were completed by 1988, but growers failed to fully utilize those ponds in 1989-90. IFREMER reports that pond usage declined further in 1990 and only 46 ha were stocked in that year (appendix B).

X. FARMS

Several groups took advantage of the assistance offered by GA and entered the industry. Eight groups have built farms, ranging in size from 3.5 to 50.0 ha of ponds. All of the farms are located in the coastal area of French Guiana (map 2). Two different types of farms exist in French Guiana. Farmers experimented with small operations (up to 5 ha of ponds) to diversify their existing crops. Some growers, however, built larger farms (averaging 20 ha) specifically dedicated to shrimp culture. Three important farms (**SAOR**,[17] **Polder Mari-Anne**,[18] and **les Hmongs Cacao Cooperative**) have reportedly closed, primarily due to marketing problems.[19] One pessimistic observer reports that these farms were some of the most progressive French Guiana groups.[20] One group reportedly began construction of a much larger farm (100 ha) in 1987, but subsequently scaled back its initial plans. As of 1990, five farms with 46 ha of ponds were operating in French Guiana (appendix B).



***Map** 2.--Map of French Guiana showing location of shrimp farms and hatcheries.*

Growers formed a trade association after the economic problems experienced in 1988. The association is the Groupement d'Intérêt Economique (GIE) which is conducting market research to coordinate export promotions.[21]

XI. METHODS AND YIELDS

Only limited information is currently available on culture methods and yields. Favorable climatic conditions permit use of the continuous growout system.[22] Ponds are filled by pumping. The water exchange rate is about 10 percent per day with frequent water quality checks. Most farms lack mechanical aeration devices, but some of the farms which have electrical lines are installing paddlewheels (AireO2). Fish are prevented from entering the ponds by filters placed at inlets. Rotenone (0.24 parts per thousand) is used to kill fish already in the ponds. The water tends to be acidic and poor in minerals.[23] Ponds are often fertilized to enhance plankton blooms. Liming ($CaCO_3$ and $CASO_4$) is mostly used, but fertilizers (chicken manure, NPK, and superphosphates) are also sometimes used. Growers generally harvest shrimp when they reach 40-45 grams using 25 millimeter mesh nets. IFREMER reports that in the continuous culture system, harvesting procedures are critical. Large blue-clawed males must be removed from the pond to induce compensatory growth of the remaining population. IFREMER has developed seines to increase fishing efficiency (lead line of 200-350 grams per meter). IFREMER believes that the nets can be further improved with mud line sliding on bottom sludges and detachable pockets.[24]

Many farmers conduct two harvesting operations each year to improve efficiency. Annual harvests have been reported of up to 2.5 t per hectare. Annual yields average 1.8 t per ha, however, because they include the results of some inexperienced farmers as well as others who were not optimally managing their farms.[25]

Production costs are not available, but are believed to be relatively high, especially given the low meat yield of freshwater shrimp.

XII. FEED

Feed is produced locally using rice and other locally available byproducts which make up a substantial part of the ingredients (appendix C).[26] Feed was available to farmers in 1990 for about $0.65 per kilogram. IFREMER's Tahiti lab has developed a formulae which it is constantly improving using a

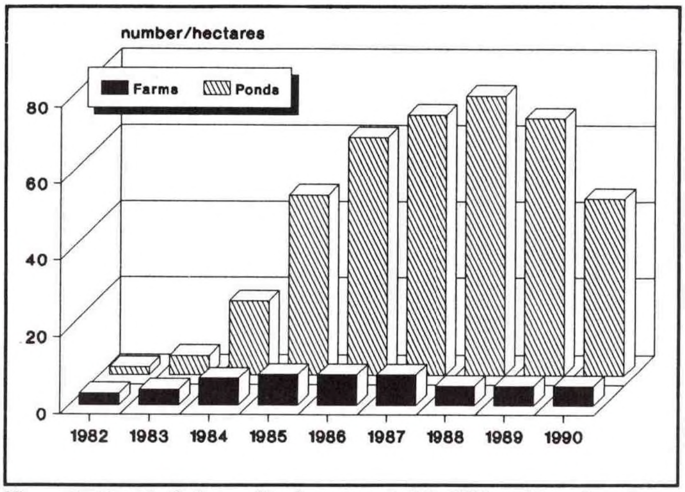


Figure 1.--French Guiana. Pond area peaked in 1988 and has since declined substantially.

fatty soluble fish protein concentrate, increased lipid content, and binders to maintain optimal water stability (2-6 hours).

XIII. HARVESTS

Harvested shrimp are killed in ice water where they are kept for 30 minutes until chilled to the core, after which they can be frozen or kept on ice for sale as a fresh product. Initially a substantial part of the harvest was frozen. Very little of the harvest is now frozen, however, as growers have turned primarily to marketing fresh product.

Harvests have fluctuated somewhat in recent years. Growers reported negligible harvests in the early 1980s (appendix B). Substantial expansion occurred beginning in 1983 when serious pond construction began (figure 1). Growers began reporting sizeable harvests in 1985 and sharply increased those harvests in both 1986 and 1987 (figure 2). Continuing pond construction and increasing experience enabled growers to harvest a record 71 t in 1987. Pond construction slowed and harvests actually declined in 1988. Growers had planned to export frozen product, but this did not prove profitable. Growers in Asia and Latin American were increasing export shipments.[27] The resulting price declines made it impossible for some French Guiana farms to continue operating.[28] Growers recovered in 1989 and reported a record 89 t harvest. The opening of a large commercial farm more than made up for the closing of three small farms. While French Guiana growers have achieved technical success, the financial results are far below initial expectations. The pond area utilized declined substantially in 1990, a particularly disturbing trend. Despite the lower number of ponds stocked in 1990 (figure 2), however, actual harvests only declined slightly (appendix B).

XIV. ECONOMIC SITUATION

The situation faced by growers in French Guiana is somewhat different than that faced on the French Caribbean islands. French Guiana growers have no shortage of available sites. On the contrary there are large areas that are not being economically utilized at this time. Growers face, however, some serious problems. The small area currently being utilized for agriculture means that there are only a limited number of farms. As a result, few farmers are available to experiment with shrimp culture as a possible diversification project. It also means the country lacks a strong agricultural sector on which shrimp growers could draw for supplies and equipment. Perhaps the most serious problem is the primitive infrastructure in many areas of French Guiana. In fact, much of French Guiana is virgin rain forrest. Large areas lack roads, electrical service, and basic communication. As a result, potential shrimp growers or other developers often are faced with very large expenditures for

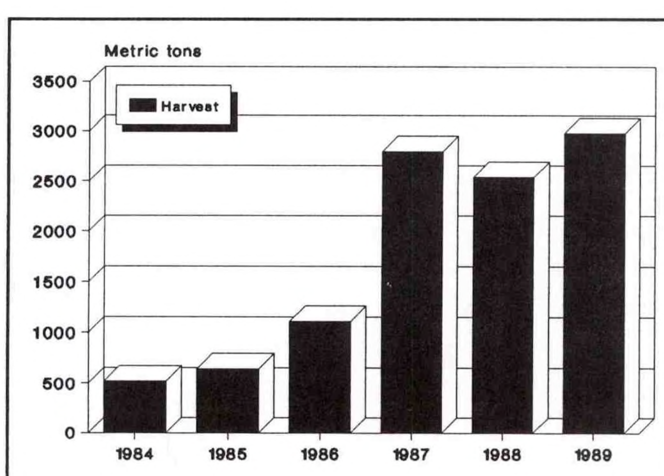


Figure 2.--French Guiana. Growers harvested a record 89 tons in 1989. The harvest declined slightly in 1990, despite a major reduction of pond area.

infrastructure projects, especially roads, that have nothing to do directly with shrimp culture. Growers on Guadeloupe and Martinique benefitted from the much more developed agricultural sector and infrastructure.[29]

XV. MARKETS

French Guiana growers face a major marketing difficulty because of the limited size of the local market. French Guiana has a population of only about 115,000 inhabitants and almost no tourist trade.[30] The local market requires only about 20 t of shrimp annually.[31] This differs from the situation on the French Caribbean Islands where freshwater shrimp is popular with local residents and the substantial tourist trade supports prices above those available to French Guiana growers.[32] Paul Magnan, SAOR founder, says that he and other French Guiana growers that entered the industry gave insufficient attention to assessing potential markets and overseas promotions.[33] The French Guiana shrimp culture industry will have to open export markets to succeed. As mentioned above, three growers had to close their farms when they were unable to compete in export markets. The early attempts to sell frozen product in the Paris Rungis market proved disappointing because they had to compete with the increasing volume of low-cost product from Southeast Asia and Latin America.[34]

French Guiana growers will have to open new export markets if they are to expand production.

European Community: Current shipments are primarily restricted to France. The growers reported considerable difficulty marketing a new product in France, especially at the relatively high prices required to cover their production costs.[35] Some success, however, has been achieved. The first exports to France began in 1987. Beginning in late 1988, small shipments of freshwater shrimp have been air freighted twice a week to France where they are sold fresh in selected markets. A total of 44 t were sold in 1989 and 36 t in 1990 under the "Crevette Bleue des Caraibes" (Caribbean Blue Shrimp) brand.[36] This represents about half of French Guiana's 1989-90 harvest. GIE reports that rather than selling at Rungis, they are marketing their product directly to retailers. French Guiana growers are now regularly supplying 50 French supermarkets.[37]

Japan: Limited efforts to enter the Japanese market have been unsuccessful, perhaps because of the competition with the increasing quantities of relatively inexpensive marine shrimp being produced in several Asian countries.

United States: Attempts to assess the United States market are not known. French Guiana used to export sizeable quantities of trawler-caught marine shrimp to the United States, but such shipments have steadily declined since 1988 (appendix E). French Guiana exported 305 t of shrimp valued at $2.4 million to the United states in 1990. U.S. import data does not separate shrimp by species, but reports from French Guiana suggest that all of this product was marine shrimp taken by trawler fishermen.[38] There have reportedly not been any shipments, of either freshwater or marine shrimp, to the United States during 1991.[39]

XVI. OUTLOOK

The industry's future is unclear. Growers have demonstrated the technical ability to culture shrimp. The future of the French Guiana shrimp culture industry is unclear. Growers have demonstrated the technical ability to culture freshwater shrimp. They harvested a record 89 tons in 1989, although the 1990 harvest declined slightly. A few farms have closed since 1987, but the remaining farms have improved growout methods and yields. The commercial viability of a major freshwater shrimp culture industry in French Guiana, however, remains to be demonstrated. The industry appears viable in countries (Brazil, Dominican Republic, Guadeloupe, and Martinique) where there is a strong local market. The success of an industry in a country like French Guiana, which would have to be based primarily on export shipments, however, remains in question. Low meat yields relative to marine shrimp, relatively high production costs, and the lack of consumer familiarity with the species currently restrict sales. As a result, French Guiana growers have experienced marketing problems. Current worldwide trends suggest that the expanding harvest of cultured shrimp worldwide may result in increasing pressure on shrimp prices. As a result, French Guiana growers may find a very difficult market environment during the 1990s. Sales of fresh product as a gourmet dish may allow the growers to successfully compete, but their ability to significantly expand export shipments has not yet been demonstrated.

The foundations for a new industry in French Guiana have been laid, but initial expectations have clearly not been achieved. Several factors suggest that the potential for an important new industry exists. French investments and advanced French research mean the industry will have adequate financial and technical support. The willingness of France and the European Community to continue supporting the industry will be critical for its future development.[40] Climatic factors and the relatively large area of available sites suggest that French Guiana has the potential to substantially expand harvests during the 1990s. The serious marketing problems associated with freshwater shrimp, however, will have to be resolved before the industry can expand significantly.

This report was originally prepared by Dennis Weidner and published as IFR-92/07 on January 10, 1992.

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IFREMER, "Les Départements et Territoires d'Outre-Mer," 1991, p. 29-31.

Mock, Cornelius in 1984. "Penaeid Shrimp Culture Consultation and Visit, French Guiana, South America," October 29-November 3, 1984.

Weidner, Dennis "Guadeloupe Shrimp Culture," *International Fishery Report*, (IFR-91/54), July 19, 1991.

____________. "Latin American Shrimp Culture, 1990-2000" *International Fisheries Report*, in press.

____________. "Martinique Shrimp Culture, "*International Fishery Report*, (IFR-91/78), September 27, 1991.

ENDNOTES

SECTION II. (Capture Fishery)

1. An excellent review of the French Guiana shrimp fishery is available in C. Dintheer, B. Gilly, J.Y. LeGall, M. Lemoine, and J. Rose, "La recherche et la gestion de la pêcherie de crevettes pénéides enGuyane française de 1958 à 1988: trente années," Inst. Francais de Recherche pour l'Exploitation de la Mer (EQUINOXE), 1989, No. 22, 21-32.

2. Excludes the catch of foreign-flag vessels.

SECTION V. (Species)

3. One such assessment was conducted by Cornelius Mock in 1984. For details see "Penaeid Shrimp Culture Consultation and Visit, French Guiana, South America," October 29-November 3, 1984.

4. Christiane Haumey, "Guyane: requiem pour la chevrette," *Pêche Maritime*, January 1991.

SECTION VI. (Initial Effort)

5. IFREMER, "Les Départements et Territoires d'Outre-Mer," 1991, p. 29.

6. Details on the shrimp culture industries of the two French Caribbean islands are available in Dennis Weidner, "Guadeloupe Shrimp Culture," *International Fishery Report*, (IFR-91/54), July 19, 1991, and Dennis Weidner, "Martinique Shrimp Culture," *International Fishery Report*, (IFR-91/78), September 27, 1991.

7. The French Centre National pour l'Exploitation des Oceans (CNEXO) merged in 1985 with the Institut Scientifique et Technique des Pêches Maritimes (ISTPM) to form IFREMER, a French government research group. France-Aquaculture, an IFREMER commercial subsidiary, has been active in many developing countries and overseas French departments where they have built both fish and shrimp hatcheries and farms. IFREMER's French Guiana Research Station is preparing a manual on freshwater shrimp culture summarizing 15 years of experience in French Guiana, French Polynesia, Guadeloupe, and Martinique. The report contains a review of the industry in each location and their development plans. IFREMER planned to publish it by the summer of 1991.

8. IFREMER, "Les Départements et Territoires d'Outre-Mer," 1991, p. 30.

9. Jean Michel Griessinger and Denis Lacroix, "Analysis for Development Plans for the Giant Freshwater Prawn *Macrobrachium rosenbergii* in the French West Indies and in French Guiana," *The Caribbean Aquaculturist*, December 1988.

10. IFREMER, "Les Départments," *op. cit.*, p.27.

11. J.M. Griessinger, H. Crieloue, and T. Robin, "Mass production of *Macrobrachium rosenbergii* postlarvae in French Guiana. Adaptation of the technique to local conditions." Paper presented at the 1st Inter-American Congress of Aquaculture, 1986, Salvador de Bahia, Brazil.

SECTION VII. (Postlarval Seedstock)

12. Philippe Gondouin and Denis Lacroix, IFREMER Station de Guyane, personal communications, February 15, 1991.

13. Philippe Gondouin and Denis Lacroix, "Status of freshwater prawn *Macrobrachium rosenbergii*, culture in the French overseas territories," IFREMER, 1990, and J.M. Griessinger, T. Pollet, and D. Lacroix, "Conception and evolution of a mass production hatchery of *Macrobrachium rosenbergii*: example of the French closed system technology applied in French Guiana," paper delivered at the III Brazilian Shrimp Conference, October 16-20, 1989, Joao Pessoa, PB.

SECTION VIII. (Research)

14. IFREMER also conducts research on freshwater shrimp at its Pacific Oceanological Center in Tahiti.

15. IFREMER, "Les Départements et Territoires d'Outre-Mer," 1991, p. 30.

SECTION IX. (Terrain/Area)

16. Guyane-Aquaculture, personal communications, July 31, 1987.

SECTION X. (Farms)

17. Japanese interests held a minority (49 percent) interest.

18. Previously owned by a Dutch group, but now operated by a French company.

19. SAOR's difficulties include some legal problems. Some of the closures appear to be temporary.

20. SAOR reportedly closed in December 1990 and the other two closed previously, but precise dates are not available. The three groups reportedly had about 74 ha of ponds. Christiane Haumey, "Guyane: requiem pour la chevrette," *Pêche Maritime*, January 1991. The *Pêche Maritime* report seems somewhat exaggerated as IFREMER reported that five farms with 46 ha of ponds continued to operate in 1990 (appendix B).

21. IFREMER, "Les Départements et Territoires d'Outre-Mer," 1991, p. 31.

SECTION XI. (Methods and Yields)

22. For details see D. LaCrroix, J.M. Griessinger, J.C. Falguiere, and T. Pollet, "*Macrobrachium rosenbergii* culture in French West Indies and French Guiana: Validity of the continuous grow-out system as a means of development," 1987, paper presented at the Caribbean Aquaculture and Trade Expo, Puerto Rico.

23. Alkalinity and hardness < 10 eq. $CaCO_3$. Gondouin and Lacroix, *op. cit.* "Status."

24. Gondouin and Lacroix, *op. cit.* "Status."

25. Gondouin and Lacroix, *op. cit.*, personal communications.

SECTION XII. (Feed)

26. Gondouin and Lacroix, "Status" *op. cit.*

SECTION XIII. (Harvests)

27. For details see Dennis Weidner, Tom Revord, and Randy Wells, "Latin American Shrimp Culture, 1990-2000" *International Fisheries Report*, in press.

28. IFREMER, "Les Départements et Territoires d'Outre-Mer," 1991, pp. 30-31.

SECTION XIV. (Economic Situation)

29. IFREMER, "Les Départements et Territoires d'Outre-Mer," 1991, p. 31.

SECTION XV. (Markets)

30. Gondouin and Lacroix, *op. cit.*, personal communications and IFREMER, "Les Départements et Territoires d'Outre-Mer," 1991, p. 29.

31. IFREMER, "Les Départements et Territoires d'Outre-Mer," 1991, p. 31.

32. Details on the shrimp market on Guadeloupe and Martinique are available in Weidner, "Guadeloupe Shrimp Culture," *op. cit.* and Weidner, "Martinique Shrimp Culture," *op. cit.*

33. Haumey, *op. cit.*

34. IFREMER, "Les Départements et Territoires d'Outre-Mer," 1991, p. 31.

35. *Ibid.*

36. Gondouin and Lacroix, *op. cit.* personal communications and Gondouin and Lacroix, "Status," *op. cit.*

37. IFREMER, "Les Départements et Territoires d'Outre-Mer," 1991, p. 31.

38. U.S. data from 1987-90 lists only frozen shipments suggesting that only marine shrimp was being shipped because freshwater shrimp was likely to have been shipped fresh. Before 1987 fresh and frozen shrimp shipments were combined in a basket category.

39. Through November.

SECTION XVI. (Outlook)

40. IFREMER, "Les Départements et Territoires d'Outre-Mer," 1991, p. 31.

APPENDICES

Appendix A.--French Guiana. Shrimp catch

Year	Quantity
	Metric tons
1984	520
1985	641
1986	1,109
1987	2,795
1988	2,541
1989	2,977

Note: Excludes the catch of foreign-flag vessels.
Source: FAO. Yearbook of Fishery Statistics, 1989.

Appendix B.--French Guiana. Shrimp ponds and harvest

Year	Shrimp Farms	Shrimp Ponds	Shrimp Harvest
	Number	Hectares	Metric Tons
1980	-	Negl.*	-
1981	-	Negl.*	-
1982	3	2	-
1983	4	5	1
1984	7	19	2
1985	8	47	15
1986	8	62	36
1987	8	68	71
1988	5	73	63
1989	5	67	89
1990	5	46	83

Negl. - Negligible
* Experimental trials
Source: Philippe Gondouin and Denis Lacroix, IFREMER Station de Guyane, personal communications, February 15, 1991.

Appendix C.--French Guiana. Shrimp feed formulae and ingredients

Contents	Proportion
	Percentage*
Feed formulae	
Proteins	28-32
Lipids	3-5
Ashes	15-18
Fiber	10
Vitamins	0.5
Ingredients	
Rice	
Broken	9
Bran	15
Wheat	10.2
Meal	
Palm	10
Soya	25
Fish**	7.5
Meat#	5
Fish protein concentrate	5
Premix##	
Calcium carbonate	7.5
Binder	0.8

* Percent of dry weight
** 64 percent protein
# 50 percent protein
Vitamins and minerals
Source: Philippe Gondouin and Denis Lacroix, "Status of freshwater prawn Macrobrachium rosenbergii, culture in the French overseas territories," IFREMER, 1990.

Appendix D.--World. Shrimp* imports from French Guiana, 1980-90

Year	Imports			Total
	U.S.	EC♦	Japan	
	1,000 Metric Tons			
1980	1.9	-	0.2	2.1
1981	1.6	Negl	Negl	1.6
1982	2.3	-	Negl	2.3
1983	1.9	Negl	Negl	1.9
1984	1.4	-	-	1.4
1985	1.0	-	-	1.0
1986	1.5	0.5	-	2.0
1987	1.0	1.4	-	2.4
1988	1.2	1.6	-	2.8
1989	0.7	2.1	0.2	2.9
1990	0.3	2.9	-	3.2
1991	-**	NA	NA	NA

Note: The United States, the European Community, and Japan account for the great bulk of world shrimp imports. French Guiana may have made shipments to other countries, but the quantities involved would be very small.
Negl - Negligible
NA - Not available
* Marine and freshwater shrimp
♦ Spain and Portugal included beginning in 1986
** Through November
Source: U.S. Bureau of the Census, EC NIMEXE, and the Japan Tariff Association.

Appendix E.--United States. Shrimp imports from French Guiana, 1980-90

Year	Imports	
	Quantity	Value
	Metric tons	US$ Million
1980	1,902	14.6
1981	1,593	14.8
1982	2,280	26.8
1983	1,941	24.8
1984	1,356	16.9
1985	955	10.1
1986	1,543	17.0
1987	1,046	9.0
1988	1,196	9.5
1989	666	5.2
1990	305	2.4
1991	-*	-*

Note: Shipments during 1987-90 were all frozen product. Product form before 1987 is not available because all shipments were reported in a fresh and frozen combined basket category.
* Through November
Source: U.S. Bureau of the Census.

Appendix F.--EC. Shrimp imports from French Guiana, 1988-90

Year	Country					Total
	France	Spain	Italy	Neth.	U.K.	
			Tons*			
1988	1,081	519	16	-	-	1,616
1989	1,663**	347	115	-	9	2,134
1990	1,834***	771	263	16	-	2,884

* Product weight
** Includes 45 kg of fresh product.
*** Small quantities of freshwater shrimp were believed to have been shipped to France during 1990, but such shipments are not noted in NIMEXE.
Sources: EC NIMEXE.

4.8

GUYANA

Guyana's commercial shrimp fishery is one of the leading local industries and an important source of export earnings. Guyana has developed a small artisanal aquaculture industry, but there is currently no commercial shrimp farming. Most observers believe that there are sites which could support a viable shrimp culture industry, but current economic conditions suggest that commercial development of those sites will be very limited during the 1990s.

CONTENTS

I. CAPTURE FISHERY

Shrimp trawling is the most important Guyanese fishery. In addition to the Guyanese fleet (64 trawlers), a number of foreign trawlers (69 trawlers) are also authorized to fish off Guyana. The Guyanese-owned vessels range from 17-23 meters (m), while most of the foreign trawlers are about 23 m long. The fishermen operate on the continental shelf at depths of 20-80 fathoms. Their vessels are equipped with double-rigged trawls.[1] The catch of *Penaeid* shrimp has been relatively stable at 400-600 metric tons (t) since 1984, but dropped to only 380 t in 1989. Foreign fishermen probably account for an additional 1,700 t of mostly *Penaeid* species, although the precise species distribution is not available. The *Penaeid* catch has dropped significantly in recent years and the Government attributes the decline to overfishing on the Guianas Banks.[2] Guyanese fishermen have reported important catches of non-*Penaeids* (seabobs) in recent years. Fishermen reported sharp seabob catch increases in 1985 and 1988. The seabob catch totaled about 3,500 t in 1989.

The Government is attempting to better manage the shrimp resource. Major management measures include: gradually reduce the fleet to 100 trawlers, implement a seasonal closure from November to January, and protect nursery areas by prohibiting trawling in shallow (less than 18 fathom) coastal waters. Government officials are also concerned that artisanal fishing is adversely affecting stocks. The artisanal fishermen use mostly Chinese and pin seins, gear which result in large catches of juveniles.[3]

II. SPECIES

Several species of shrimp are commonly found in Guyanese waters. The principal *Penaeids* are *Penaeus aztecus, P. brasiliensis, P. duorarum, P. notialis P.schmitti,* and *P. subtilis.* The non-*Penaeids* include *Xiphopenaeus kroyeri* and *Palaemon schmitti*.

Map 1.--Map of Guyana.

III. COMMERCIAL AQUACULTURE PROJECT

One state corporation, the **Guyana Sugar Corporation** (GUYSUCO), has attempted to culture both Louisiana crawfish and freshwater shrimp. It set aside about 80 hectares (ha) of land for various aquaculture projects. GUYSUCO began experimenting with crawfish culture in 1987. The project was delayed because officials were concerned that the crawfish could damage Guyana's important irrigation system. Apparently GUYSUCO determined that this concern was unfounded and imported 0.3 t of live crawfish from Louisiana in June 1987. About one-third of the June shipment died in transit and GUYSUCO subsequently arranged for an additional 0.15 t shipment. The trials were conducted at the Blairmont Sugar Estate. GUYSUCO has also built several freshwater shrimp ponds in 1987 and hoped to stock them with postlarvae (pl) imported from Panama or other countries. A GUYSUCO technician was to have been trained in Panama. GUYSUCO plans included the construction of a freshwater shrimp hatchery in 1988. The company encountered, however, a variety of technical problems.[4] GUYSUCO had hoped to attract a joint venture partner. Preliminary discussions were held with several foreign groups, but no agreement was reached. As a result, the company has terminated its shrimp culture project. Officials remain interested, however, in possible future projects.[5]

IV. ARTISANAL AQUACULTURE PROJECTS

While there are no commercial aquaculture projects specifically dedicated to farming shrimp, quite a number of private farmers do conduct artisanal culture operations in brackish water fish ponds. These farmers report small incidental shrimp harvests. The U.S. Embassy in Georgetown reports that about 65 such farms, averaging over 10 ha of ponds each, were active in 1990.[6] The total pond area is about 670 hectares. This activity is especially prevalent near the Surinamese border in the Berbice area (figure 1). Farmers conduct selective harvests on a continuous basis. Pl and juveniles naturally present in the water serve as seedstock. The most prevalent shrimp species reported by the farmers are: *Xiphopenaeus kroyeri, Penaeus schmitti, P. aztecus, P. subtilis, P. duorarum*, and *P. brasiliensis*. FAO reports that the primary species is seabobs (*X. kroyeri*)[7]. Natural tidal flows introduce eggs, larvae, and fry into the ponds along with nutrients. The farmers also rely on tidal fluctuations for water exchange.

Guyanese artisanal farmers harvested about 170 t of shrimp in 1989. Pond yields averaged only 0.2-0.3 t annually.[8] While low in comparison to results at successful extensive shrimp farms in other Latin American countries, the Guyanese farmers are achieving respectable yields given the limited investment and accompanying harvest of finfish. Extensive shrimp farmers with ponds built specifically to culture shrimp in some other countries do not report such favorable results. Not only are the farmers reporting small profits, but they are gaining invaluable experience that could prove very helpful for future commercial aquaculture development.

V. GOVERNMENT POLICY

The Guyanese Government would like to promote the aquaculture industry, but resources are limited. The Government currently provides little or no assistance to the farmers, nor does it regulate the industry. The country's fisheries development plan targets aquaculture as an area with considerable potential. Development will require, however, investments in infrastructure, equipment, and planning. The Fisheries Department in the Ministry of Agriculture provides some assistance through research, extension services, and training.

VI. CREDIT

The Government has only a limited capability to assist the industry with needed financing and is reportedly interested in attracting foreign investment. The Government has submitted project proposals to various multilateral lending agencies. Government officials would also like to attract private investors, both domestic and foreign. New measures announced in the 1987 budget were specifically designed to interest potential investors. Companies which export outside the Caribbean Community (CARICOM) are allowed to keep 20 percent of their export earnings in hard currency. The National Assembly in 1987 considered legislation to make exporters eligible for tax deductions of up to 50 percent on earnings from export shipments, but the law was never enacted.[9] While government and foreign investors are active in Guyana's shrimp trawl fishery, no private investor has yet initiated a shrimp culture project. The inability to attract foreign capital and technical assistance has been a major factor impairing the industry's development.

VII. LEGAL FRAMEWORK

Officials believe that the industry should be monitored and organized, especially land allocation and utilization. Various Guyanese laws indirectly establish the legal basis for the aquaculture industry. Some coastal land is state property.[10] Landowners along rivers have title up to the median high tide.[11]

This report was originally prepared by Dennis Weidner and published as IFR-91/60 on August 9, 1991.

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2. Terrence C. Phillips, Principal Fisheries Officer, "Main Aspects of Fisheries Management in Guyana," *Workshop on Socio-economic Implications of Fisheries Management in the WECAFC Region*, November 8-9, 1990, pp. 6-8.

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5. John A. Piggott, Agricultural Manager-Technical, Guyana Sugar Corporation, personal communications, August 1, 1990.

SECTION IV (Artisanal Aquaculture Projects)

6. U.S. Embassy, Georgetown, August 29, 1990.

7. FAO. "Aquaculture Production" *FAO Fisheries Circular*, No. 815.

8. Fisheries Department, "Data on Shrimp Culture in Guyana," August 1990.

SECTION VI (Credit)

9. One long-established U.S. joint venture (Georgetown Seafoods Ltd.) is reportedly operating with a skeleton staff and may be forced to close down due to taxes on shrimp, high fuel costs, and the refusal of the Government to grant profit retention concessions. "Georgetown Seafoods Facing Closure," *Staloverk News*, October 28, 1990 and "Shrimp Trawlers Still Idle," *Catholic Standard* October 21, 1990.

SECTION VII (Legal Framework)

10. Guyana's developing aquaculture industry is complicated by the Sea Defenses Act (Cap. 64:01) which reserves sea defenses (land 50 feet leeward from the center of a sea or river wall and all land on the other side of the sea or river dam to the toe of such sea or river dam or river wall) as state property.

11. Guyana Civil Law Act (Cap. 6:01, Sect 4.).

APPENDICES

Appendix A.--Guyana. Cultured shrimp harvest

Year	Quantity
	Metric tons
1980	-
1981	-
1982	Negl
1983	Negl
1984	10E
1985	15E
1986	53
1987	36
1988	NA
1989	40E*

E - Estimates
NA - Not available
* The U.S. Embassy estimates 170 tons.
Sources: NMFS (1980-84 estimates);
FAO. "Aquaculture Production"
FAO Fisheries Circular, No. 815,
various years.

4.9

PARAGUAY

Paraguay is a landlocked country situated in the heart of South America. It is surrounded by Argentina, Brazil, and Bolivia. The climate is highly variable. The temperature in Asunción, which is located in the south along the Paraguay River, averages 21°C during the winter (May through September), falling to 13°C in June. During the summer (December to February) temperatures often exceed 38°C. The country is divided by the Paraguay River into two distinct regions (map). Eastern Paraguay lies in the temperate region and consists of gently rolling country with wooded hills, tropical forests, and fertile grasslands. Annual rainfall averages about 150 centimeters (cm), but is subject to substantial local and annual variations. Western Paraguay, usually called the Chaco, is a low, marshy plain covered with dense scrub forests. Westward from the Paraguay River and the meandering, unnavigable rivers which flow into it, the land becomes drier and water more scarce. Rainfall in the Chaco averages about 80 cm annually, although practically no rain falls from June through August.

***Map 1**.--Map of Paraguay.*

Paraguay has developed a small aquaculture industry concentrating on carp, tilapia, and a native catfish species. The development is unique in Latin America as it has occurred spontaneously by small landowners with virtually no Government assistance.[1] Growers produce almost entirely for local consumption.

There are no known shrimp culture projects in Paraguay.[2] As the country is landlocked, the industry would be limited to freshwater shrimp. A U.S. farmer living near Ytororo, however, repeatedly conducted a successful trial with freshwater shrimp in 1991. The National University of Asunción provided technical assistance. The trial has reportedly been suspended due to lack of financing.[3]

Local officials believe that there is considerable potential for warmwater aquaculture in the eastern region of the country where water is more available, particularly near the Parana and Paraguay Rivers. These areas, are located at more southerly latitudes than most of the Brazilian projects[4] and cooler temperatures would result in lower growth rates. Shrimp farmers in Argentina, however, have initiated projects at even more southerly latitudes than Paraguay.[5] The absence of Paraguayans with technical backgrounds in aquaculture, especially shrimp culture, suggest that the local aquaculture industry will continue to focus on finfish for the foreseeable future. Any significant development of a local shrimp culture industry appears unlikely at this time.

This report was originally prepared by Dennis Weidner as IFR-92/03 on January 10, 1992 and slightly revised on July 21, 1992.

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ENDNOTES

1. A good, but somewhat dated, description of Paraguayan aquaculture is available in "Plan Nacional para el Desarrollo de la Acuicultura en Paraguay," *Planificacion de la Acuicultura en America Latina,* ADCP/REP/76/3, and R.O. Smitherman and D.D. Moss, "Fishculture Survey Report for Paraguay," Project AID/csd-2270, September 20, 1970.

2. Jonathan Farrar, Economic and Commercial Attache, U.S. Embassy, Asunción, personal communications, January 25, 1991.

3. U.S. Embassy, Asunción, July 20, 1992.

4. For details see Dennis Weidner, "Brazilian Shrimp Culture Industry," *International Fishery Report,* (IFR-90/92), December 21, 1990.

5. For details see Dennis Weidner, "Argentine Shrimp Culture," *International Fishery Report*, (IFR-91/68), August 23, 1991.

4.10

PERU

Peru has developed an important shrimp culture industry. The country has many of the same environmental conditions as neighboring Ecuador, the region's largest shrimp producer. Suitable sites and climate, however, are restricted to a small area along the northern coast. Growers, following developments in Ecuador, began experimenting with shrimp in 1971 and opened the first commercial farms in 1975. The industry has since grown considerably, reaching harvests of 5,000 tons in 1990. Some growers are intensifying pond management and improving yields. Many, however, are reporting sharply higher production costs, which have forced some growers to idle ponds. In addition, Peru's serious economic problems may slow the industry's expansion. Despite these problems, many observers believe that increasing yields should lead to expanded harvests during the 1990s. The small potential area available for additional ponds suggests that expansion will be limited. Harvests are unlikely to exceed 10,000 tons by the year 2000.

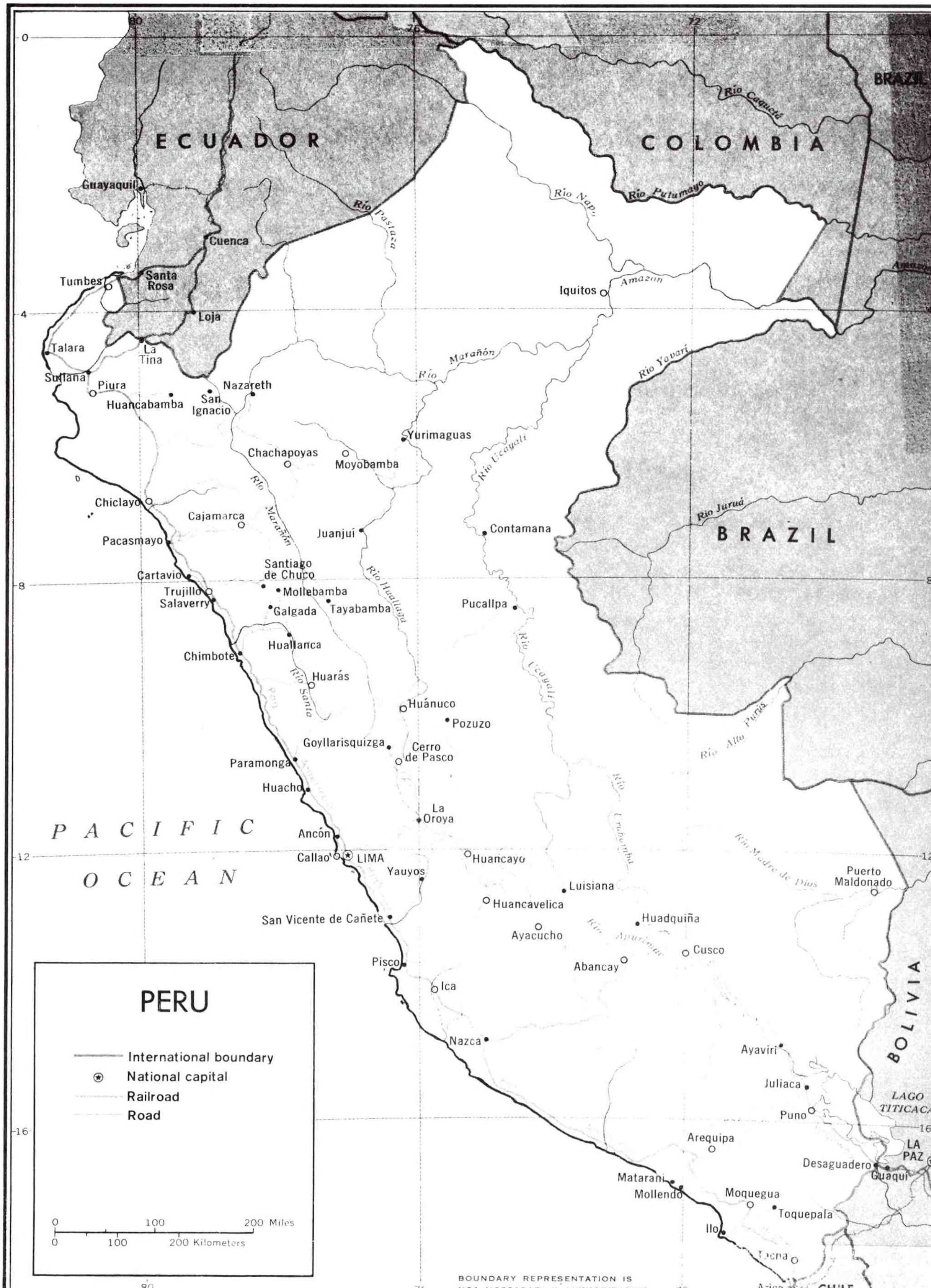
CONTENTS

I. AREA/LOCATION

Peru has a relatively small area of potential shrimp culture sites. Most estimate the potential area to be about 10,000 hectares (ha).[1] No detailed analysis is available, however, explaining how these estimates were calculated. They do not appear to represent precise inventories verified with on-site inspections. Instead, they appear to include a substantial area of sites with less than ideal characteristics, many of which may not prove economically viable. Some would require the pumping of large quantities of water, necessitating considerable expenditures for fuel.

Only two provinces, Tumbes and Piura, appear to have conditions suitable for culturing shrimp. Colder climatic conditions prevent cultured operations further south.[2]

Tumbes: Most Peruvian farms are located in the tidal areas and estuaries of Tumbes Province along the southern edge of the Gulf of Guayaquil bordering Ecuador. The best sites are near the mouth of the Tumbes River, the only significant permanent source of freshwater along Peru's northern coast. Tumbes is



Map 1.--Map of Peru.

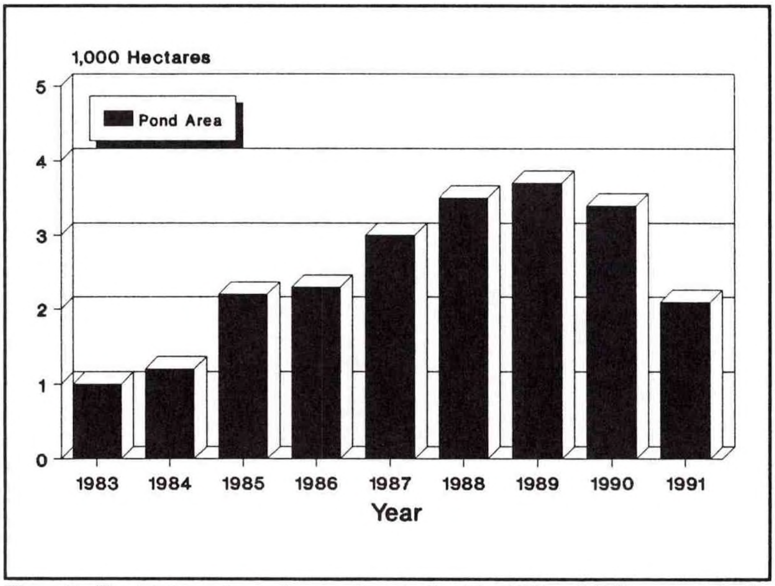


***Figure 1.**--The total pond area in operation declined in 1990 and 1991 as a result of increasing production costs, which forced growers to idle ponds.*

the only Peruvian province with mangrove forestry providing a suitable nursery environment for tropical shrimp and thus a source of postlarvae (pl). The mangrove area is limited, however, to a small 30-40 kilometer (km) length of coast.[3] Growing conditions in Tumbes are quite similar to those found in Ecuador's El Oro Province, an important region of Ecuador's dynamic shrimp culture industry.[4]

Piura: A few farms have also been built further south in Piura Province. It is not yet established, however, if conditions in Piura will support commercially successful farms. More limited freshwater resources will create pond management problems and somewhat cooler seawater temperatures will lower growth rates. One observer reports that the cooler climate may limit the number of crops growers can harvest per year.[5] Some observers also report higher water salinities.[6] In addition, Piura is distant from the mangrove areas of Tumbes Province and southern Ecuador where pl can be collected. One observer claims, however, that trial runs performed in 1989-90 showed that shrimp culture operations were viable.[7]

Peruvian growers have steadily expanded pond area during the 1980s. One observer reports that growers have built around 5,000 ha of ponds.[8] Growers have generally reported fairly high pond utilization rates. The total pond area utilized reached a high of 3,700 ha in 1989. Growers began to idle small numbers of ponds in 1990, and pond usage was significantly reduced in 1991 (appendix B and figure 1). One observer estimates that growers only stocked 2,100 ha of ponds in 1991, a 35 percent decrease from the area stocked in 1990.[9] The Asociacion Langostinera Peruana (ALPE) reports that growers were forced to cut back their operations and idle ponds because of escalating production costs.[10]

Some observers believe that Peru still has considerable potential to expand pond area. Others claim that most of the best suited sites have already been developed. The best possibility for expanding the industry appears to be the conversion of low-lying agricultural lands currently producing rice and bananas in the Tumbes area. This could provide around 2,000 hectares.[11] Some growers have already built such ponds, and additional ponds are currently under construction.[12] The economics of converting agricultural land, however, is unclear. While much of the area could theoretically be converted to shrimp ponds, land owners may find current agricultural activities more profitable. One observer reports that an additional 6,000 ha of uncultivated land could also be converted.[13] Uncultivated land, however, may prove more costly to develop because of location or additional land clearing expenses. An additional option is development further south in Piura province, but the profitability of such operations is not yet known.

II. CLIMATE

Peru offers acceptable, but not ideal climatic conditions for culturing tropical shrimp. Northern Peru is the southern limit of the Pacific-coast tropical *Penaeid* shrimp used by growers, so small declines in water temperature can create adverse conditions for tropical shrimp. Coldwater not only adversely affects spawning, greatly reducing the availability of pl in estuaries, but creates poor growing conditions for juvenile shrimp. The coast of Peru is affected by a cold current, the Humboldt Current, which runs along the country's coastline. This feeds relatively cold water into equatorial latitudes that would otherwise support a tropical ecosystem, explaining why shrimp can only be cultured in the most northerly provinces.

Peru's shrimp culture industry, as in Ecuador, is also periodically affected by the *El Niño* climatic

Photo 1.--Peru. The country's cultured shrimp harvest far exceeds the small quantities caught by fisherman. Dennis Weidner

event. The *El Niño* event manifests itself in a cyclical but unpredictable pattern--normally occurring around every 5 years--producing increased rainfall and abnormally warm ocean temperatures. *El Niño* events can have disastrous consequences. Peru was devastated by the 1982-83 *El Niño*, which destroyed roads, bridges, and villages all along the northern coast. The 1986-87 *El Niño* also affected the country, but on a much smaller scale. Although *El Niño* events can have a disastrous impact on the country as a whole, the effects on the shrimp aquaculture industry are positive. Warmer ocean temperatures result in the increased availability of wild pl and better shrimp growth. Harvests increased dramatically during both the 1982-83 and 1986-87 *El Niños* (appendix C1). NOAA reported in the summer of 1991 that an *El Niño* event was in progress, and predicted that it would reach its peak in late 1991 or early 1992, suggesting that 1992 may offer especially favorable growing conditions.

III. FARMS

The Peruvian shrimp culture industry consists of many relatively small farms. One estimate suggests that over 70 shrimp farms were operating during 1991 and 25 more were planned or under construction.[14] Farms average 50 to 60 ha,[15] but vary from 4 to 280 hectares (appendix D). All shrimp farms are owned and operated by the private sector,[16] many of them through associations of small investors.

IV. METHODS/YIELDS

Most Peruvian farms employ semi-intensive techniques. Observers report yields varying from 1.0-2.0 metric tons (t) per hectare.[17] Growers appear to be making progress in improving yields. Production and pond area data (appendices B and C) suggest that average yields have grown from around 1.0 t per ha in 1989 to 1.5 t per ha in 1990. Given the relatively small area available for shrimp culture, many growers have no choice but to improve yields if they want to increase harvests. A few growers are employing more intensive methods, improving water circulation, adding aeration, and intensifying supplemental feeding. These growers have achieved substantially higher yields, varying from 2.5-3.0 t per hectare. Growers average 2.0-2.5 harvests per year, depending on conditions.[18] One company, **Inca Shrimp**, is preparing a 1 ha covered pond in Tumbes to experiment with intensive culture, using a stocking density of more than 60 pl per square meter.[19] No details on results, however, are yet available.

V. PRODUCTION COSTS

Peruvian growers are reporting sharply increasing production costs, largely due to the rising cost of fuel and shrimp feed. Peru's efforts to intensify operations and increase stocking densities have necessitated fuel to run aerators and supplemental feed application.

Fuel: Higher fuel prices are the result of the Peruvian Government's overall economic policies. The Government eliminated subsidies and increased taxes on fuel during the summer of 1990, substantially raising domestic prices. Some observers report that the high cost of fuel, which is used to run generators and pumps, is the most serious problem facing shrimp growers today, and represents over 30 percent of the final production cost.[20] This is much higher than fuel costs facing growers in most other countries.

Photo 2.--Peru. Many growers still rely on artisanal collections for postlarval seedstock. Dennis Weidner

Feed: One report indicates that feed costs rose over 30 percent between August 1990 and the summer of 1991. The exact reasons for the rapid increase in the price of feed are unknown.[21] The Peruvian Government has reportedly restricted imports of shrimp feed, which has lessened competition.[22] One report indicates that shrimp feed prices are twice as expensive as in Ecuador.[23]

Other: Expenses for two other important factors--pl seedstock and labor--have also reportedly risen rapidly.

The result of these substantial cost increases for the major production factors have been a substantial increase in overall production costs. One observer estimates that average cost to produce a kilogram (kg) of shrimp increased from $4.60 in August 1990 to $9.60 during the summer of 1991.[24] This is substantially higher than the average costs reported in neighboring Ecuador[25] and has reportedly led some growers to idle ponds, partially explaining the decrease in Peru's pond utilization rate.

VI. SPECIES/POSTLARVAE SUPPLIES

The species favored by Peruvian growers is *P. vannamei*, which accounts for as much as 95 percent of the country's harvest. The remainder is *P. stylirostris*, incidentally cultured along with *P. vannamei*.[26] Pl of both species is obtained from the estuaries running from Punta Capones to Punta Mero.[27] Pl is also obtained from Ecuadorean suppliers and increasingly from domestic hatcheries. Three domestic hatcheries (**Bioltecsa**, **Tecnomar** and **Perusa**) have a capacity to produce about 60 million pl per month.[28] Actual production averages 40-50 million pl per month. The most productive hatchery is Bioltecsa, which produces half of the country's hatchery pl, or about 25 million pl per month. Demand for pl in 1990 was reportedly greater than supply. The growers' tendency to intensify operations is increasing demand. Two new hatcheries are under construction and operators expect to have them operational during 1991.[29] The current *El Niño* may improve the availability of wild pl in 1991 and 1992, but no information is available at this time. The Comite de Acuicultura de la Asociacion de Exportadores del Peru (ADEX) in 1989 obtained European Community (EC) aid to build additional hatcheries and improve the operations at existing hatcheries.[30]

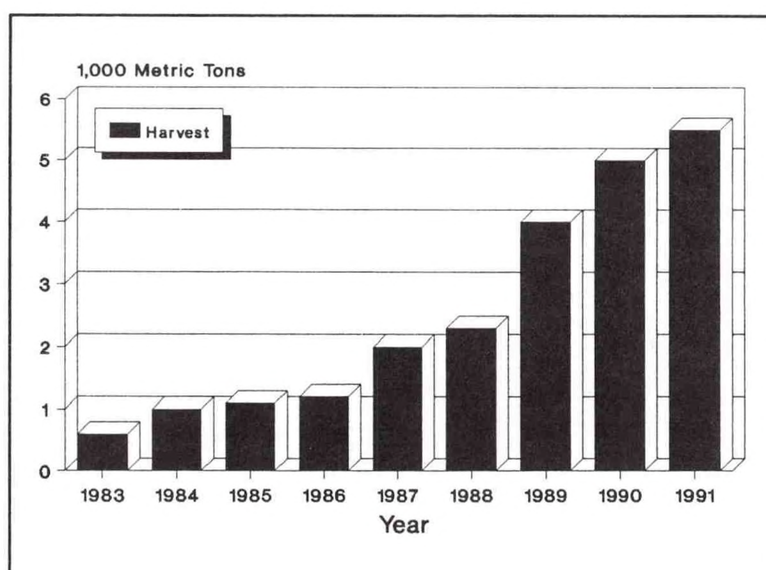


Figure 2.--Harvests have risen steadily as a result of increased pond area and higher yields.

Photo 3.--Peru. Packers in the Tumbes area have significantly increased shimp production as a result of the new shrimp culture industry. *Dennis Weidner*

VII. HARVESTS

Peruvian harvests have increased steadily since 1983. Growers have reported impressive increases from only 600 t in 1983 to 5,000 t in 1990 (appendix C1 and figure 2). The sharp increases in 1983 and 1987 were primarily due to the warm water temperatures associated with *El Niño* events. The substantial 1989 and 1990 increases were reportedly due to improved pond management and increased stocking densities.[31] The 1991 harvest situation is difficult to assess. The sharp decline in pond utilization (appendix B) suggests that the harvest should decline. Data for 1991 are not yet available, but exports to the United States (appendix E) suggest that the 1991 harvest will actually be slightly higher than in 1990. This is probably the result of improved yields and the 1991 *El Niño* event.[32] These two factors have allowed growers to maintain the harvest level, despite the decline in pond utilization. Peruvian harvests grew significantly during previous *El Niño* years (1983 and 1987). Growers in neighboring Ecuador have reported substantially higher harvests during the first 6 months of 1991 due to the warmer water temperatures and increased pl supplies associated with the *El Niño*.

Peruvian growers continue to report one of the largest harvests in Latin America. Ecuador is the major producer, but the only other country to exceed Peruvian harvests is Colombia (appendix C2). Several countries, however, have more potential than Peru to expand pond area and harvests. As a result, the Peruvian industry may decline relative to other Latin American countries during the 1990s.

VIII. PROCESSING/EXPORTS

Growers during the 1970s and early 1980s delivered the harvest to the same packing plants used by the small trawler fleet to process shrimp. The larger farms now operate their own processing plants, which pack both their own harvest and the harvests of smaller neighboring farms. Several plants in the Tumbes region process shrimp. The four largest companies have the capacity to process over 65 t per day.[33]

Most of Peru's cultured shrimp is exported; Peruvian domestic shrimp consumption is very limited. Most of the export-grade shrimp is shipped as tails to the **United States** (appendix E). Shipments of Peruvian shrimp to the United States have averaged 2,100 t since 1985. Shipments totaled 2,200 t in 1990, a 20 percent increase over the 1,800 t exported in 1989. Shipments during 1991 were little changed, although the value increased slightly. Peru, like several other Latin American countries, has begun exporting whole shrimp to the growing **European Community** (EC) market. Shipments reached 770 t in 1990. European 1991 data is not yet available, but most observers believe that shipments will continue to increase. Shipments to **Japan**, the world's largest import market, are negligible.

The cholera (*Vibrio cholerae*) outbreak in early 1991 which initially began in Peru and later spread to Ecuador and Colombia caused a temporary reduction in Peruvian shrimp exports. Several Latin American (Argentina, Bolivia, Brazil, Colombia, and Ecuador) and European (France, Italy, and The Netherlands) countries initially restricted Peruvian seafood imports. The largest buyer of Peruvian shrimp--the United States--did not prohibit imports of Peruvian seafood products. The U.S. Food and Drug Administration (FDA), however, issued an import alert requiring 100 percent sampling of Peruvian seafood at the U.S. port of entry.[34] No samples of Peruvian shrimp were found to be contaminated. The Public Enterprise for Fishing Certificates (CERPER) is the Peruvian Government agency responsible for inspecting seafood and issuing certificates of sanitation. Many

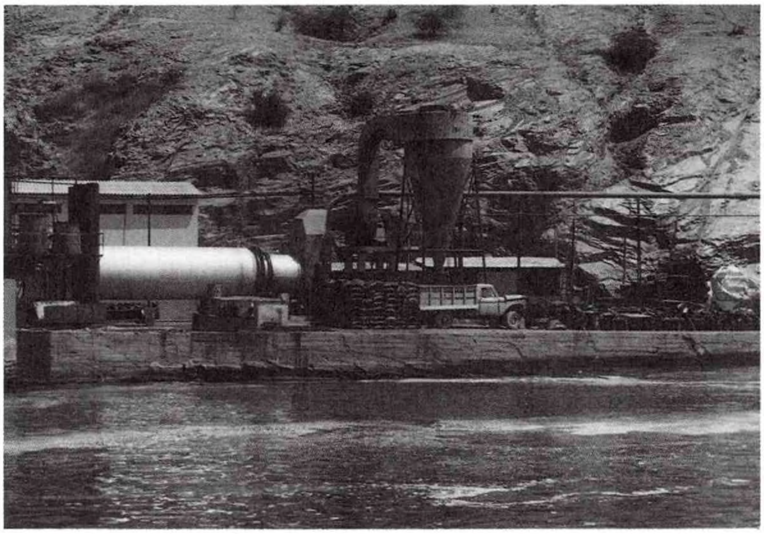


Photo 4.--Peru. The country's massive fishmeal industry provides plentiful domestic supplies of fishmeal for aquatic feed production. *Dennis Weidner*

observers believe that Peru may experience repeated cholera outbreaks during the summer months as a result of the primitive sanitation conditions in many cities. As a result, the long-term impact on the shrimp and other food industries is not yet known.

IX. FEED

Several domestic feed producers supply the shrimp culture industry. Largest of these is **Nicovita** (Nicolini Hermanos S.A.), which supplies about 70 percent of the Peruvian market and is reporting success in export markets. Other feed producers include **Molinos Takagaki** and **Purina del Peru**.[35] Producers initially used the same mills that produced other animal feeds.[36] Nicovita and Molinos Takagaki have now both constructed plants exclusively dedicated to shrimp feed. Peru is one of the world's major producers of fishmeal, a major ingredient of shrimp feed. Despite this advantage, Peruvian feed prices are reportedly high and are a major expense for shrimp growers.[37]

X. CREDIT MARKET

One of the most serious problems currently facing Peruvian shrimp growers is difficulty in securing loans. Peru faces a severe credit shortage, mostly due to the country's high foreign debt. Interest rates are prohibitively high, and few Government loans specifically directed to the shrimp culture industry are available. This has severely restricted the industry's ability to expand. Some growers also report difficulties obtaining operating capital, which may be one of the reasons for the large number of underutilized ponds.

XI. GOVERNMENT POLICY

Recent Peruvian Governments have put a heavy emphasis on state involvement in the economy and industry groups have accused them of being ambivalent, if not hostile, to the private sector. Many growers complained of regulations complicating efforts to export.[38] Government macro-economic policies--especially exchange rate policies--exacted a heavy toll on exporters. Up to mid-1990, the Government controlled the exchange rate of the Peruvian currency, the *inti*. The official exchange rate overvalued the *inti*. Exporters thus earned fewer *intis* (at the official inflated rate) per dollar than the free-market rate. In effect, it was a substantial tax on exporters, who lost the difference between the value of *intis* received per dollar and the true value of *intis* which would have been received at free market rates. The Government tried to alleviate some of the burden on exporters through Export Certificates (CERTEX), which provided a bonus to exporters.[39] Nevertheless, the number of *intis* received per dollar, even with CERTEX payments, were still lower than the free exchange rate. This reduced the income of shrimp growers and led to illegal shipments of shrimp through Ecuador to avoid the unfavorable conversion rate.[40]

The current Fujimori Administration has made some attempts to liberalize the Peruvian economy and lower tariffs. The Administration and the Central Reserve Bank, in August 1990, announced reforms creating a single exchange market for foreign currency transactions based on supply and demand for the dollar.[41] Shrimp exporters have greeted the new system with enthusiasm and believe that it will stop the illegal shipments of shrimp through Ecuador.[42] The Government has also lowered tariffs rates on some goods. Observers, however, report that shrimp growers still face high Government tariffs on many capital goods.[43]

The Peruvian Government has attempted at different periods to promote the shrimp culture industry. The Ministry of Fisheries (MIPES) in the early 1970s conducted research to aid early growers.[44] MIPES continues to recognize the industry's potential and has been promoting its development by authorizing duty-free imports of some equipment and supplies for the construction of crustacean and mollusk hatcheries.[45] The overall fiscal problems faced by the country, however, seriously restrict the ability of MIPES and other agencies to offer any significant promotion program.

XII. LEGAL FRAMEWORK

MIPES is the government agency responsible for aquaculture through the recently created General Directorate for Aquaculture. Shrimp culture activities are regulated under Decree No. 002-89-PE, which established guidelines for Government concessions for shrimp ponds as well as other legal authorizations, such as permits for collecting seedstock.[46]

XIII. FOREIGN ROLE

Foreign groups have played a limited role in the development of Peru's shrimp culture industry. Domestic investors have been the primary force behind the industry's development. The authors know of no U.S.-owned farms, probably because of Peruvian laws which discourage foreign investment.[47] In addition to Government policy, some figures in the Peruvian fishing industry have taken a generally unfavorable attitude towards U.S. investment.[48] U.S. consulting groups have reported little activity in Peru. The principal foreign group assisting the industry has been the European Community. Under the direction of ALPE, EC aid supports a soil and water analysis laboratory.[49] EC assistance has also been obtained for hatchery and pl research.[50] The EC, between 1986-89, organized conventions which brought Andean (Peru, Ecuador, and Colombia) shrimp growers, technicians, and exporters together to discuss common interests.[51]

OUTLOOK

Peruvian growers have achieved substantial success during the 1980s developing a shrimp culture industry. Growers have expanded pond area and harvests dramatically. Pond area has increased from 1,000 ha in 1983 to over 5,000 ha in 1990, and harvests have increased from 600 t to around 5,000 t during the same period. Some progress has been achieved by hatcheries, although growers still report periodic difficulties obtaining adequate pl throughout the year. Peruvian growers are adopting increasingly sophisticated pond management techniques, and report some of the highest yields in the region.

Several factors appear to be impeding the industry's further development. Production costs--especially the cost of fuel and feed--have risen substantially. This has forced growers to idle a large number of ponds. The depressed Peruvian economy, in addition, poses difficulties for investors, who must cope with a high inflation rate and difficulty in securing credit. The Fujimori Government has implemented policies aimed at controlling inflation and attracting foreign investment, which may help growers. Higher production costs, however, will continue to restrict expansion.

Increasing yields should lead to continued expansion in harvests during the 1990s if growers can bring escalating costs under control. The small potential area available for additional ponds, however, suggests that expansion will be limited. Harvests are unlikely to exceed 10,000 t by the year 2000.

This report was originally prepared by Tom Revord and Dennis Weidner and published as IFR-91/91 on December 6, 1991.

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ENDNOTES

SECTION I (Area/Location)

1. Ricardo Molina, Director, Asociacion Langostinera Peruana, personal communications, August 19, 1991 and Ulises Munaylla, "La Actividad Langostinera," *Pesca*, July/August 1991.

2. See Section II "Climate."

3. Christian Berger, Nicolini Hermanos, personal communications, February 18, 1991.

4. See Tom Revord and Dennis Weidner, "Ecuadorean Shrimp Culture," *International Fishery Report*, in press.

5. Molina, *op. cit*. This is a key factor as fewer crops would make it difficult for Piura growers to compete with growers in other countries. Growers in Tumbes, for, example, are reporting two or more crops per year.

6. Italo Salgado, "Nursery and Growout of *Penaeus Vannamei* at High Salinities: Integrated Farming of *Penaeid* Shrimp and Artemia," *Larvaculture and Artemia Newsletter*, March 1991.

7. Salgado, *op. cit.*

8. Munaylla, *op. cit.*

9. Molina, *op. cit*. The actual portion may be larger as accurate estimates of total pond area are not available.

10. See Section V "Production Costs."

11. Molina, *op. cit.* and Berger, personal communications, February 18, 1991.

12. Berger, personal communications, August 3, 1990.

13. Molina, *op. cit.*

SECTION III (Farms)

14. Christopher Denmark, AM Quality Foods, "Shrimp Farming in Peru," *World Shrimp Farming*, March 1991.

15. Christian Berger, "Crianza de Langostinos," in *Pesca*, July/August 1991.

16. Pedro Noriega-Curtis and José Vera Rivas, F.A.O. *Regional Survey of the Aquaculture Sector in Latin America*, 1989.

SECTION IV (Methods/Yields)

17. Berger, personal communications, August 3, 1990 (1.0 t/ha) and Munaylla, *op. cit.* (2.0 t/ha). Precise yield data is unavailable. Yield data is compiled by individual companies and often considered confidential information.

18. *Aqua-O2 News*, May 1990.

19. *Fish Farming International*, December 1990. Nicovita has reportedly made efforts to encourage more intensive operations, FAO *Globefish Highlights*, January 1991.

SECTION V (Production Costs)

20. "Implementacion de Planta Piloto Tumbes," *Pesca*, November-December 1990.

21. See Section IX "Feed."

22. Molina, *op. cit.*

23. Denmark, *op. cit.*

24. Munaylla, *op. cit.*

25. The limited information currently available suggests that production costs of about $2.50-4.00 per kg of shrimp in Ecuador. Ecuador's lower production costs may largely be the result of lower feed costs. One observer reports that feed prices are subsidized in Ecuador. Molina, *op. cit.* For further information, see Tom Revord and Dennis Weidner, "Ecuadorean Shrimp Culture," *International Fishery Report*, in press. Some caution should be exercised in comparing these estimates. Many sources providing cost data often do not specify how these estimates were calculated, making meaningful comparisons difficult.

SECTION VI (Species/Postlarvae Supplies)

26. No known freshwater ponds are in operation; one group of investors is reportedly considering freshwater operation near Arequipa. Leandro Quispa Mamani, Centro de Investigacion y Extension en Recursos Naturales (CIERNA), personal communications, April 16, 1991. Freshwater shrimp pl are reportedly produced by Durhan-Mayo, outside of Lima. For more information, see J.M. Oliviera and J.C.G. Gastelu "Commercial Larviculture of *Macrobrachium Rosenbergii* in a Closed System in Peru," *Larviculture and Artemia Newsletter*, Number 15, March 1990.

27. "Diagnóstico situacional de la actividad extractiva de post-larvas de langostino (*P. vannamei*) en Tumbes." Instituto del Mar, 1990.

28. Berger, personal communications, February 18, 1991.

29. Denmark, *op. cit.* Peru imports a large amount of *Artemia*, which is used to feed hatchery postlarvae. Observers report that Peru has the potential to harvest enough *Artemia* for domestic demand and export. See J. E. Vinatea, Profesor y Consultor de Acuicultura, Universidad Nacional Agraria, La Molina, "El Peru Puede Convertirse en el Mayor Productor de *Artemia* en America Latina," unpublished study.

30. *El Peruano*, February 1, 1989.

SECTION VII (Harvests)

31. Berger, personal communications, February 18, 1991.

32. This may also be a reflection of Peru's market diversification.

SECTION VIII (Processing)

33. Molina, *op. cit.*

34. Charles Thurston, "FDA Requires Full Inspection of Peruvian Imports," *Seafood Supplier*, May/June 1991. The FDA generally inspects only about five percent of all imported food.

SECTION IX (Feed)

35. Berger, personal communications, August 3, 1990.

36. Doreen Gillespie, "Shrimp in Peru," *Fish Farming International*, December 1990.

37. See Section V "Production Costs."

SECTION XI (Government Policy)

38. Sjef van Eys, "Shopping for Fish and Seafood in Latin America Can be Rewarding," *Quick Frozen Foods International*, April 1991.

39. Berger, personal communications, August 3, 1990.

40. *Chile Pesquero*, February 1989. These illegal shipments can be highly variable, with illegal shipments also going from Ecuador through Peru, depending on the exchange rate policies of the Ecuadorean Government.

41. *Telivisión Peruana*, August 10, 1990. The Peruvian Government intervened in the exchange rate market in mid-May 1991. The Government announced "temporary" measures to counter the rise of the dollar against the inti. *Lima Radio Nacional del Peru*, May 24, 1991.

42. Luis Cavarso, University of Indiana, personal communications, September 15, 1990.

43. Molina, *op. cit.*

44. One observer maintains that a Government experimental farm played an important role in promoting the industry. Munaylla, *op. cit.*

45. Under Article 99 of the General Law of Fisheries, shrimp farm operators are allowed tax exemptions or lower tax rates under certain conditions. Munaylla, *op cit.*

SECTION XII (Legal Framework)

46. Munaylla, *op. cit.*

SECTION XIII (Foreign Role)

47. The Peruvian Ministry of Fisheries has begun to seek foreign investment in the fisheries sector. It is unknown how this will impact the shrimp culture industry. See Doreen Gillespie, "New Peruvian Minister Puts Challenge to His Industry: Bring in Ships to Replace Russians," *Fishing News International*, October 1991.

48. See Alejandro Bermejo, "¡No a la inversion extranjera!" *Expreso*, July 15, 1991.

49. Molina, *op. cit.*

50. *El Peruano*, February 1, 1989. See Section VI "Postlarvae Supplies."

51. Munaylla, *op. cit.*

APPENDICES

Appendix A.--Peru. Addresses

Shrimp exporters

Cerro Azul
Augusto Tamayo 180, 3 piso
Lima 27, Peru
TEL: (51-14) 415622; 401736

Claver SRL
Jose Galvez 711
Apartado Postal 18-1341
Lima 18, Peru
TEL: (51-14) 466231; 456798

Commercial Exportadora
Miguel Seminario 320, Of. 301
Lima 27, Peru
TEL: (51-14) 423185; 428309

Cultivos Tecnificados del Mar
Jr. Republica de Chile 284
Lima 27, Peru
TEL: (51-14) 424829; 424830

Cultivos Tecnificados del Mar-CULTECMAR
Libertad 416, Of. 304
Piura, Peru
TEL: (51-14) 327043

Dumar
Av. La Pax 439, Of. 901
Lima 18, Peru
TEL: (51-14) 443251; 466049

Frigorificos Ransa
Av. Argentina 2951
Callao 1, Peru
TEL: (51-14) 652424; 287840

Import/Export Pacific - SRL
Colon 705 Trujillo LA
Libertad, Peru
TEL: (51-14) 241307

Interpro
Av. Canada 1160
Apartado Postal 339
Lima 13, Peru
TEL: (51-14) 715312; 724141

Inversiones Alimentarias del Peru
Gral. Pershing 187, Of. 201
Lima 18, Peru
TEL: (51-14) 473467

Inversiones Nueva York
Av. Jose Pardo 138, 8 y 9 piso
Lima 18, Peru
TEL: (51-14) 452790

Langostinera Boton de Oro
General Iglesias 608
Lima 18, Peru
TEL: (51-14) 473251; 520241

Langostinera Santa Gertru
Av. Canada 230
Lima 13, Peru
TEL: (51-14) 722282; 722639

Langostinera Tumbes
Chinchon 907, 3 piso
Lima 27, Peru
TEL: (51-14) 423699

Langostinera Tumpis
Jr. Tarata 277
Lima 18, Peru
TEL: (51-14) 441370

Ligabue International Catering
Chinchon 875, Of. 802
Lima 27, Peru
TEL: (51-14) 421284; 228546

MAI
Av. Primavera Este 120, Of. 415-A
Apartado Postal 180179
Lima 33, Peru
TEL: (51-14) 356498

Mar Norte
Schell 343, Of. 206
Lima 18, Peru
TEL: (51-14) 444139; 443908

Perupesca
Jr. Alfonso Ugarte 321
Lima 32, Peru
TEL: (51-14) 612049; 618934; 618979

Plasticos El Pacifico
Av. Maquinarias 6015
Apartado postal 4315

Callao 3, Peru
TEL: (51-14) 527140

Procesadores de Product Marinos del Norte
Mz. 252, Lte. 5
Piura, Peru
TEL: (51-14) 329003

Productos Marinos Referigerados
Av. Costanera 2200
Lima 32, Peru
TEL: (51-14) 527240

Pruductos Marinos Refrigerados
Av. Javier Prado Oeste 1381
Apartado Postal 166
Lima 27, Peru
TEL: (51-14) 416084; 418093

Purina Peru
Camio Real Centro Comercial
Torre Pilar, Piso 11
Lima 27, Peru
TEL: (51-14) 316111; 918578

Refrigerados Tumbes
Av. Republica de Panama 3680, Piso 6
Lima 27, Peru
TEL: (51-14) 418244; 418875

Feed Companies

Cogorno
Zona Industrial de Ventanilla s/n
Callao, Peru
Telephone: (51-14) 881283

Molinos Takagaki
Autopista a Ancón, Km. 13.5
Lima, Peru
Telephone: (51-14) 233959

Nicovita (Nicolini Hermanos)
Pasaje Villegas s/n
Callao, Peru
Telephone: (51-14) 651458
FAX: (51-14) 651458

Nutripaisa
Tambo Grande S-45
Dept. 202 Urb. Santa Ana
Piura, Peru
Telephone: (51-14) 322818

Purina del Peru
Panamericana Norte, Km. 17.5
Lima, Peru
Telephone: (51-14) 316111

Appendix B. -- Peru. Shrimp pond area, 1983-91

Year	Area
	Hectares*
1983	1,000
1984	1,200
1985	2,200
1986	2,300
1987	3,000
1988	3,500
1989	3,700
1990	3,400
1991	2,100

* In production
Sources: Christian Berger, Nicolini Hermanos, personal communications, August 1990 (1983-86); Aqua 02 News, May 1990 (1987-89); Ricardo Molina, Director, Asociacion Langostinera Peruana, personal communications, August 19, 1991 (1990-91).

Appendix C1. -- Peru. Cultured shrimp harvest, 1983-91

Year	Quantity
	1,000 Metric tons*
1983	0.6
1984	1.0
1985	1.1
1986	1.2
1987	2.0
1988	2.3
1989	4.0
1990	5.0E
1991	5.5E

E - Estimated
NA - Not available
*liveweight equivalent
Sources: Christian Berger, Nicolini Hermanos, personal communication, August 1990 (1983-88); Gary Rogers, Aeration Industries in World Shrimp Farming, November 1990 (1989); Ulises Munaylla, in Pesca, July-August 1991 (1990).

Appendix C2--Latin America. Cultured shrimp harvests, 1985-91

Country	Year 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	6.0E	9.8P
Mexico	0.1	0.2	0.8	2.4	3.2E	5.5E	NA
Honduras	0.6	1.3	1.9	4.5	3.4	5.0E	NA
Panama	2.6	3.0	2.8	3.5	3.5E	NA	NA
Peru	**1.1**	**1.2**	**2.0**	**2.3**	**4.0**	**5.0E**	**5.5E**
Brazil**	0.6	0.7	1.0	1.4	2.0	2.5E	NA
Guatemala	0.5	0.6	0.8	0.8	0.8	1.1E	1.5P
Others	0.8	1.0	1.0	1.6	1.8E	1.5E	NA
Total	36.6	51.8	80.0	87.9	85.9	100.0E	135.0P

E - Estimated
NA - Not available
P - Projected
* Liveweight equivalent
** Includes substantial quantity of freshwater shrimp.
Source: Variety of country sources, NMFS data and estimates.

Appendix D.--Peru. Marine shrimp farms, 1991.

Company	Ponds
	Hectares
San Isidro	90
Cerro Negro	110
Victoria Scrl.	100
Santa Cruz-Misole	120
Cultecmar	130
Mar Norte	180
Aquatecnica	200
Paracas	280
Others*	890
Total	2,100

* Approximately 60 farms
Source: Ricardo Molina, Director, Asociacion Langostinera Peruana, personal communications, August 19, 1991

Appendix E.--United States. Shrimp imports from Peru, 1980-91.

Year	Imports Quantity	Value
	1,000 Metric Tons	US$ Million
1980	0.7	4.0
1981	0.9	5.7
1982	1.3	9.6
1983	4.3	35.9
1984	3.0	24.0
1985	2.0	17.3
1986	1.7	16.0
1987	2.7	21.4
1988	1.9	14.0
1989	1.8	14.9
1990	2.2	16.7
1991	2.2	16.9

Source: U.S. Census Bureau

4.11

SURINAME

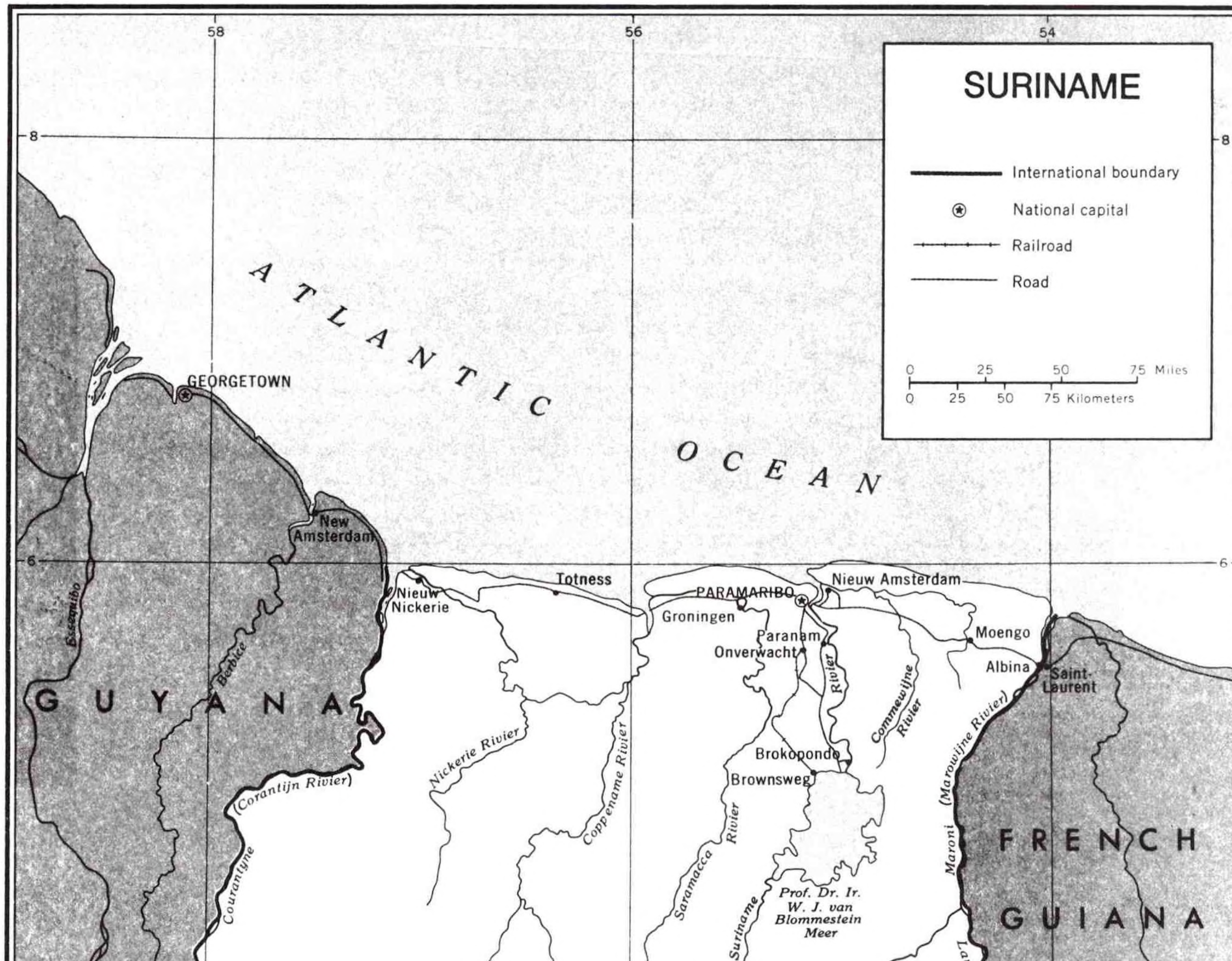
Suriname offers some suitable sites for both marine and freshwater shrimp culture. The country will require foreign technical and financial support to develop its potential because few Surinamese have the needed technical skills. Local companies have conducted preliminary trials with freshwater shrimp, but have been hampered by difficulties in obtaining foreign technical support. Some freshwater harvests appear possible, but they are unlikely to exceed 500 metric tons by the year 2000. The more technically demanding requirements for marine shrimp culture suggest limited prospects for development in the foreseeable future. Overall, given the country's need for foreign assistance and the economic and political situation which discourages foreign involvement, the industry's prospects appear very limited during the 1990s.

CONTENTS

I. CAPTURE FISHERY

Surinamese fishermen conduct primarily artisanal operations, but there is some commercial fishing.

The artisanal fishery is primarily conducted in inshore waters and to a lesser extent estuaries and rivers. It is conducted by rural families, mostly to supply local markets. There are few vessels capable of operating at sea. One report (1982) indicated that about 8 boats of about 13 meters (m) and 120 smaller vessels were operating in inshore waters. The fishermen make trips of about 7-10 days. Other fishermen use dugout canoes and open, narrow-beamed caravels for estuarine and river fisheries. Most are powered with small outboard motors. Fishing methods are primarily gillnets, drift nets, stationary gear (stake nets or pin seines and Chinese seines), liftnets, longlines, and hook and line. Only a few traps are used. **Gillnets** are set in coastal water at depths from 1-10 meters. The gillnet catch consists mostly of catfish, *Sciaenids*, croakers, sea trouts, mackerels, jacks, sharks and rays, snooks, tarpon, and mullet. **Driftnets** are set from about 120 boats. The nets are about 2 kilometers (km) long and always set in shallow water. The catch is primarily *Sciaenidae* and *Ariidae*. The **steak net or pin seine** is about 1.6 km long with 5 centimeters (cm) meshes. The nets are held by a semi-circular row of stakes and are set on mud flats during high tide. The catch includes shrimp, mullet, dog trout, snook, catfish, *Sciaenids*, rays, and sharks. The **Chinese seines** are set mostly at the mouths of the main rivers and at Matapica. The nets are conical bags about 12-15 m long with a mouth opening of roughly 4-9 meters. The net is attached to wooden stakes positioned on mud banks. The catch is mainly shrimp (sea bob and *Penaeids*) and various finfish (dog trout, butterfish, and catfish).



Map 1.--Map of Suriname.

Large numbers of immature fish are caught in the nets. They are discarded, but usually do not survive. **Lift nets** are used in the estuaries to catch shrimp (seabob). **Bottom longlines** (200-1,000 hooks) are used in the estuaries, primarily to catch catfish. Primitive **traps** are used to catch mullet, snook, and tarpon, primarily at the locks of the country's agricultural canal system.

Suriname also has a small commercial fishery. **Shrimp:** The major commercial fishery is for shrimp. It is conducted largely by foreign fishermen, mostly Japanese and Koreans. The Government issues licenses to about 140 trawlers averaging about 24 m in length. The fishermen primarily target *Penaeus subtilis* and *P. brasiliensis*, and to a lesser extent *P. notialis* and *P. schmitti*.[1] Precise data on the species composition is not available because the fishermen and processors do not keep data divided by species.[2] The fleet is generally deployed in coastal waters of at least 30 meters. Fishing is conducted year-round.[3] Annual shrimp landings during the 1980s averaged 5,000 metric tons. The shrimp industry is of some importance to the local economy, although official statistics reveal a slightly negative trend line.[4]

Other species: Other commercial fisheries are limited to small fisheries for snapper/grouper and shark. About 30 Venezuelan vessels regularly apply for Surinamese licenses to catch snapper/grouper. A few Surinamese vessels also deploy gillnets to catch sharks.

II. AQUACULTURE INDUSTRY

Suriname has very extensive freshwater resources and the potential for developing a significant aquaculture industry. The country has several important rivers and a major freshwater lake (map). The country's fishing industry, however, is based almost entirely on capture fisheries and very little progress has been made in developing an aquaculture industry. Only a few attempts have been made to initiate aquaculture projects. Some growers attempted to culture tilapia in the 1950s. Problems developed with the escape of the tilapia into the wild and competition with indigenous species. The only other notable efforts have been to experiment with shrimp. Suriname does not currently report any cultured harvests. Aquaculture falls under the State Commission for Fisheries which with a state company (Surland) has been the primary force attempting to promote the industry's development.

III. GROWING CONDITIONS

Suriname benefits from a variety of favorable environmental conditions which support the local shrimp stocks. The primary factors are an extensive shelf and significant mangrove estuaries fed by several rivers (map). The extensive deposition of sediments has resulted in thick mud banks developing along the coast. While creating favorable conditions for shrimp, these mud banks and the extensive estuarine system separate the coastal population from the sea, and partially explain the country's very limited marine fishery.

Potential growers face a variety of problems. Some of the difficulties encountered by growers wishing to farm marine species along the coast are described below. Both marine and freshwater growers face problems resulting from the absence of a national land use policy. Observers are especially concerned with the heavy use of pesticides by the expanding agricultural sector, especially in rice fields.

IV. MARINE SHRIMP

Suriname has no marine shrimp farms. Some groups, however, have expressed an interest. Estimates as to the area suitable for shrimp culture vary substantially. The U.S. Embassy in Paramaribo reported in 1987 that about 3,800 hectares (ha) of ponds could be built, but such estimates do not appear to have been based on any detailed survey.[5] Government officials point out that a more detailed survey of the coastal zone is required. Most of the coast consists of mud banks deposited by several rivers and edged by extensive estuaries. Some land is very low-lying, which would create water circulation problems for shrimp and finfish farmers, other areas have high levels of organic material, and others may be toxic due to sulfate acid soils.[6] One preliminary report indicated that low salinities at some of the better sites would complicate commercial development for marine species.[7]

Preinvestment assessments by private investors have reportedly suggested that investments would not prove profitable. **France:** The Government contracted France Aquaculture in 1986 to evaluate the country's potential for marine culture. Subsequently, France Aquaculture conducted an assessment for a private group, financed by the European Community Centre pour le Développement Industrial. The pilot phase of the study may begin some time in 1991 and France Aquaculture provided technical assistance.[8] **FAO:** FAO conducted a preliminary study in 1986-87 and reached sharply different conclusions.[9] FAO believes that a substantial coastal area could be developed. FAO estimated that 30,000 ha or more could be utilized for shrimp growout ponds.[10] FAO found that the growing conditions were favorable and the country had the potential to culture shrimp.[11]

Even some of the most optimistic observers believe that development at many sites could prove difficult. Most of the better potential sites are located at some distance from Paramaribo (map) in areas with limited infrastructure, complicating construction and subsequent growout operations. The soil at many of these sights is heavy clay and while it can be used for ponds, construction may prove costly. Building marine shrimp farms in such a coastal area may prove difficult, but Government officials insist that investors should not dismiss Surinamese opportunities.[12]

V. FRESHWATER SHRIMP

Freshwater shrimp farming has attracted the greatest interest in Suriname. Fishery Department officials, however, are less enthusiastic, believing that earnings from such projects would be marginal.[13] As in other countries, one of the primary concerns freshwater shrimp growers face would be a stable market. The focus on freshwater shrimp is primarily due to the greater availability of freshwater shrimp postlarvae (pl) and the less sophisticated technology needed for freshwater shrimp culture. The problems faced by marine shrimp growers described above have also encouraged local groups to concentrate on freshwater projects.

Various groups have initiated small pilot-scale projects for freshwater shrimp. Two groups have carried out the most important effort.

J. Surland N.V. (a quasi-government agency which exports bananas) reportedly conducted trial runs on a few ha of ponds during 1987. The ponds were situated at a banana plantation near Jarikaba. SURLAND operated a hatchery capable of producing 1 million freshwater shrimp pl annually.[14] The company hoped to expand annual production to 10 million pl in 1990, but the project was terminated in 1990 due to the resignation of its director and the departure of two experts.[15]

Commewijne Shrimp and Fisheries (COMVIS) also began experimenting with a few ha of ponds in 1987. The company operated 1.8 ha of test ponds in 1990 using semi-intensive methods. Farm operators claim impressive annual yields of 3.0 metric tons (t) per hectare. Pl were obtained from the company's own hatchery and from a hatchery in French Guiana.[16] The project is conducted by the Fernandes Verenigde Bedrijven company and their partner Van Alen. Fernandes finances the operation and Van Alen provides technical advice. COMVIS is planning a major expansion program and hoped to obtain assistance from various international donors (especially Dutch assistance[17]), but is currently operating its farm only on an experimental basis because of the difficulties which have developed with foreign assistance programs. Major donors are insisting that the Surinamese Government adopt a structural adjustment plan before additional assistance funds are disbursed. COMVIS eventually hopes to build 90 ha of ponds, some of which are already under construction. The U.S. Embassy confirms, however, that current activities are at a virtual standstill.[18]

VI. HARVESTS

No harvest data exists to assess the current state of the industry. One report estimated that about 15 t of shrimp was harvested in 1987[19], although this is not confirmed by other sources and more recent U.S. Embassy reports suggest that only negligible quantities are being harvested.[20] FAO reports negligible harvests through 1989.[21]

VII. ECONOMIC CONDITIONS

The Surinamese Government is interested in promoting the development of the country's aquaculture industry. Government policy, however, currently provides no special assistance to the shrimp culture industry, although the possibility of the Government providing soft loans, tax advantages, and the use of Government land has been discussed. The current unstable political and economic situation, however, will make it very difficult for new aquaculture projects. The decline of the Surinamese guilder and the Government's unrealistic official exchange rate creates problems for groups desiring to convert investment funds or foreign exchange earnings. Businessmen often are literally forced to resort to illegal currency exchanges and export practices. Other illegal acts are sometimes necessary to obtain needed imports, such as seedstock, feed, and fertilizers. Unfortunately success in such operations could prove just as important as technical success in the actual aquaculture operations. The economic problems are critical. Development of a local shrimp culture industry is highly dependent on attracting foreign investment because of the limited expertise available in Suriname and shortages of investment capital. The unstable political situation and declining economy, however, discourage potential foreign investors.[22]

VIII. FOREIGN ASSISTANCE

While investors have been generally unwilling to commit funds, several foreign groups are helping to develop Suriname's shrimp culture industry. The **Organization of American States** (OAS) helped Surland build both its original demonstration ponds in 1984 and its hatchery. **FAO** provided $0.2 million in 1986 to assess the possibility of culturing marine shrimp in the Commewijne District.[23] **China** had agreed to provided a $2.3 million loan for shrimp culture projects, primarily freshwater projects. The funds were to be administered by the Surinamese National Development Bank.[24] Surland reportedly received a $1.0 million long-term loan under that program.[25] The Government also hoped to obtain additional assistance from **Indonesia** and **Korea**. The current status of these loans, however, is unknown as a result of the termination of the Surland project. The **European Community** is promoting a structural adjustment plan for Suriname. The fisheries sectorial plan reportedly includes some provision for aquaculture. The Fishery Department has asked the European Development Fund (Lome IV) for about $4.33 million to assist local aquaculture investors. **France** through its IFREMER Group (France Aquaculture) has provided assistance to both the Government and private groups.

IX. PROSPECTS

Future projections are highly speculative, and not particularly encouraging. Development is likely to center primarily on freshwater shrimp culture. Much will depend on the future of the COMVIS project. If it proves successful, Surinam during the 1990s could achieve small freshwater harvests of 150-300 t, and substantially more if additional growers begin operations and succeed in developing export markets. Such projections, however, are somewhat optimistic. Other countries attempting to develop export markets have reported difficulties. Limited quantities could be sold locally, but any major development of Suriname's freshwater shrimp culture industry would have to depend on the success of export marketing efforts. No marine shrimp culture projects are currently planned. While there do appear to be some suitable sites, development is unlikely at this time. Marine shrimp culture projects would require extensive foreign technical and financial support and investors are unlikely to make such commitments in the current unstable economic and political environment.

This report was originally prepared by Dennis Weidner and published as IFR- 91/96 on December 27, 1991.

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ENDNOTES

SECTION I. (Capture Fishery)

1. The most recent survey of the shrimp fishery is included in "Conditions and Prospectives of the Deepsea Fishery and the Deepsea Processing in Suriname," CESWO: Paramaribo, May 1989, P. Charlier, *The Potential of the Suriname Fishery* EOF Project No. 6605-36.59.003, April 1989. Another source suggests that *P. aztecus* is also important. U.S. Embassy, Paramaribo, August 22, 1990.

2. Pierre Charlier, "Suriname's Fisheries Potential," *EC Fisheries Cooperation*, December 1989, Vol. 2, No. 4, pp. 5-10.

3. U.S. Embassy, Paramaribo, August 22, 1990.

4. Local observers report, however, that during the 1980s there has been a remarkable growth of the artisanal fishery for finfish, particularly the coastal gillnet fishery.

SECTION IV. (Marine Shrimp)

5. U.S. Embassy, Paramaribo, May 14, 1987.

6. Dirk Pottier, Fisheries Department, personal communications, January 4, 1991, and February 22, 1991.

7. U.S. Embassy, Paramaribo, May 14, 1987.

8. Michel Autrand, France Aquaculture, personal communications, April 17, 1991.

9. Some of the FAO assessment was prepared by France Aquaculture. See France Aquaculture/FAO, "Demonstration farm for marine shrimp culture in Suriname," May 1987.

10. Pottier, *op. cit.*

11. Hendrikson Associierte Consultants (HAC) and Surinamese Fisheries Department, "Analyse van de Surinaamse Visserij," part II, 1987.

12. Pottier, *op. cit.*

SECTION V. (Freshwater Shrimp)

13. Pottier, *op. cit.* and FAO, "Analyse van de Surinaamse Visserij," part II, 1987.

14. The company released very little information about its operations and this information is not confirmed.

15. U.S. Embassy, Paramaribo, November 9, 1990.

16. For details on the situation in neighboring countries see Dennis Weidner "French Guiana Shrimp Culture," *International Fisheries Report*, in press, and Dennis Weidner "Guyana Shrimp Culture," *International Fisheries Report*, (IFR-91/60), August 9, 1991.

17. COMVIS requested Dutch assistance through the Surinamese Planning Bureau, but such aid is uncertain at this time due to difficulties which have arisen with regards to Dutch-Surinamese cooperation.

18. U.S. Embassy, Paramaribo, November 9, 1990.

SECTION VI. (Harvest)

19. U.S. Embassy, Paramaribo, May 14, 1987.

20. U.S. Embassy, Paramaribo, August 22, 1990, September 26, 1990, and November 9, 1990.

21. FAO, "Aquaculture Production (1986-89)" *FAO Fisheries Circular No. 815*, Revision 3.

SECTION VII. (Economic Conditions)

22. HAC and Surinamese Fisheries Department, *op. cit.*

SECTION VIII. (Foreign Assistance)

23. *Network News*, No. 5, September 1986. The FAO Technical Cooperation Programme projects were: TCP/SUR/6651 and TCP/SUR/8952. Full details are available in D. Detante, *et.al*, "A report prepared for the project for the development of marine shrimp culture in tidal ponds," FAO, 1987.

24. CANA (Bridgetown), November 21, 1986, and Paramaribo Domestic and International Service, May 5, 1987.

25. U.S. Embassy, Paramaribo, September 26, 1990.

4.12

URUGUAY

Uruguay has not yet developed an aquaculture industry. Artisanal fishermen conduct only a small shrimp fishery. Various groups have conducted some preliminary shrimp culture research, but results are not encouraging. The country's temperate climate limits growth rates and growers would have difficulty competing with the high yields growers achieved in tropical countries. Any significant commercial development of a shrimp culture industry appears unlikely during the 1990s.

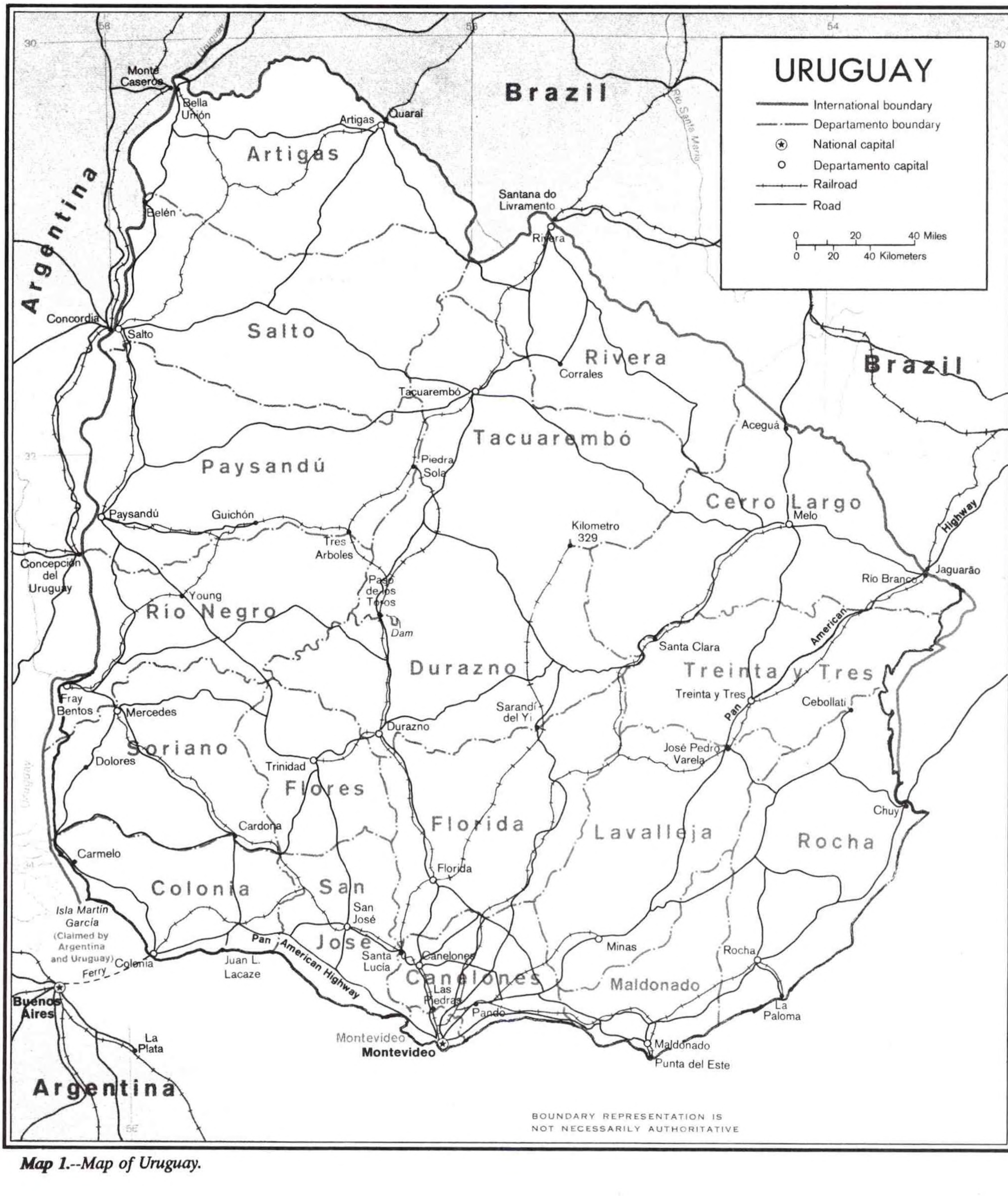
CONTENTS

I. AQUACULTURE INDUSTRY

Uruguay has not yet developed an aquaculture industry. Since 1985, the Uruguayan Instituto Nacional de Pesca (INAPE) has conducted various studies to assess the country's aquaculture potential. No significant commercial development, however, has yet taken place. Commercial development will probably not occur until the overall economic situation improves.[1] Obtaining investment funds for commercial ventures has been particularly difficult as there have been no successful domestic projects to demonstrate that aquaculture is commercially feasible. INAPE has expressed special interest in catfish and has done some work at a research station at Constitción, Salto.[2] INAPE has also expressed interest in marine shrimp, citing the relatively high price and strong international markets.[3] The industry, given the limited availability of domestic technical expertise, needs to attract foreign technical assistance and investment. Potential foreign investors, however, have so far expressed little interest in Uruguayan aquaculture opportunities.

II. CAPTURE FISHERY

Uruguay has the smallest shrimp fishery of any coastal South American country. The fishery is conducted by artisanal fishermen. The primary species taken is *Penaeus paulensis*, a white *Penaeid* which constitutes about 75 percent of the catch. Other species present include *Artemesia longinaris* and *Pleoticus muelleri*, the two species which dominate the Argentine shrimp fishery further south. Most of the catch is taken in the coastal estuaries of Maldonado and Rocha Departments which are a southern continuation of the Brazilian estuaries. Catches generally total 10-50 metric tons (t) annually, but seasons of up to 100 t have been reported. The 1990 catch was about 80 tons. Catches are highly variable as a result of climatic factors. The single



Map 1.--Map of Uruguay.

most important variable is the constant opening and closing of the connections between the estuaries and the sea. If the connections are open, permitting postlarvae (pl) to enter and juveniles to leave, Uruguay can report a good season. If the connections are closed by deposition and mud/sand bars, a poor season usually occurs.[4] Catches are seasonal and mostly taken from March to May. Almost all of the catch is currently sold in domestic markets. One observer reports 1991 retail prices of about $15 per kilogram.

III. FARMS

No Uruguayan groups have yet built shrimp farms.[5] Some Uruguayan farmers, however, have expressed interest in shrimp culture as a potential diversification from existing crops.[6]

IV. RESEARCH

Various groups have conducted limited research on both marine and freshwater species.

A. Marine species

Uruguayan biologists began working on shrimp culture in 1971. The only marine species known to have been studied in Uruguay is *P. paulensis*. Researchers selected the species because it is the primary indigenous marine species and the Atlantic *Penaeid* most tolerant of cold water.

INAPE research has concentrated in the Jose Ignacio, Garzon, Rocha, and Castillos lagoons.[7] INAPE officials believe that Uruguay's coastal estuaries, especially sites near the mouth of the Maldonado River, could offer favorable environmental conditions. INAPE researchers conducted some work in 1979. Little work was done on growout, but some important findings were reported on pl availability in the Arroyo Valizas/Laguna Castillos. INAPE attempted to maintain juveniles in a laboratory for reproduction studies, but had difficulty maintaining acceptable temperature levels.[8] A variety of research results have been published.[9] INAPE reports conducting some work on reproduction in 1984 with assistance from the Taiwan Aid Mission. The Government planned to build a pilot shrimp farm, but no details on the results of that project are available. INAPE reports that it is currently conducting some work on marine shrimp culture as part of an agreement with the Intendencia Municipal de Rocha.[10]

Uruguayan officials would like to supplement shrimp catches with cultured harvests. Researchers have only begun, however, to conduct studies on the potential for marine shrimp culture in the country. INAPE is also studying stocks in the coastal estuaries. INAPE plans to expand its research work and is about to complete construction of a new marine laboratory at La Paloma, Rocha Department.

B. Freshwater species

Uruguayan groups have also demonstrated interest in freshwater shrimp. Some biologists are convinced that freshwater shrimp may have potential in Uruguay. INAPE began a program in 1982 to study the feasibility of culturing freshwater shrimp at its Laboratorio de Acuicultura Marina at Palma near La Paloma.[11] One group has conducted some research on *Macrobrachium borelli*, primarily to determine the feasibility of culturing it as possible feed for cultured fish.[12]

Local researchers soon turned to *M. rosenbergii*, which was first imported for study in 1984. Both pl and juveniles were obtained from Panama. Research included work on reproduction, larviculture, growout, and maintenance of broodstock.[13] Researchers wanted to assess yields and were concerned about winter survival, given the temperate Uruguayan climate.[14] The Government of Taiwan provided some assistance to INAPE which has reported successful experimental harvests and planned to build a hatchery in 1985[15]. Observers reported some difficulties with pollution at the site.[16] The project was terminated after Uruguay broke diplomatic relations with Taiwan and recognized mainland China in 1986.

INAPE resumed research efforts in 1989 when new pl were obtained in Panama. INAPE reports annual yields of 0.2-0.6 t per hectare using semi-intensive growout methods. While INAPE views the yields achieved to date relatively low, researchers consider them satisfactory as demonstration results.[17] INAPE researchers are currently preparing details of the results for publication.

V. PROSPECTS

Prospects for a Uruguayan shrimp culture industry are not favorable. Uruguayan researchers have done some limited research on shrimp culture, both marine and freshwater species. Some suitable sites exist. Other factors suggest that the development of a shrimp culture industry at this time is unlikely. The country's temperate climate, lack of an aquaculture industry, and lack of domestic technical expertise suggest that no significant commercial development will occur during the 1990s.

This report was originally prepared by Dennis Weidner and published as IFR-91/63 on August 9, 1991.

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"Exitosa Experiencia del Cultivo de Bagre Negro," *El Dia,* August 27, 1982.

Galli, L. "Estudio Preliminar de la Produccion de *Macrobrachium borelli* (Nobili, 1896) en estanques de tierra," *IV Congreso Nacional de Veterinaria*, 1987.

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_________. "Informe sobre la Explotación y Cultivo de Camarones *Peneidos* en Uruguay," *INAPE Informe Técnico*, 1986.

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_________. "Informe preliminar sobre las posibilidades de cultivo de langostino *Penaeus paulensis* Perez-Farfante en lagunas salobres de Uruguay," *FAO Informes de Pesca*, No. 159 Vol. I (SE/17).

ENDNOTES

SECTION I (Aquaculture Industry)

1. Dr. Gabriel Rodriguez Marques, personal communications, December 27, 1990.

2. Commercial development is possible in the rice paddies in the east and north and in the reservoir of the Bonete hydroelectrical project in the central area of the country. Diego de Posadas, Presidente de la Comisión de Desarrollo de la Cuenca del Rincón del Bonete, personal communications, April 10, 1991.

3. Lic. Mónica Spinetti, INAPE, personal communications, June 20, 1991.

SECTION II (Capture Fishery)

4. Spinetti, *op. cit.*

SECTION III (Farms)

5. De Posadas, *op. cit.*

6. Spinetti, *op. cit.*

SECTION IV (Research)

7. For details see F. Villegas, "Informe preliminar sobre las posibilidades de cultivo de langostino *Penaeus* paulensis Perez-Farfante en lagunas salobres de Uruguay," *FAO Informes de Pesca*, No. 159 Vol. I (SE/17).

8. F. Villegas, "Estado Atual do Cultivo do Camarao no Uruguai," *Anais di I Simp. Bras. sobre Cultivo do Camarao*, Natal, 1981.

9. See for example: R. Mazzoni, "Experiencias de Inducción de la Maduracion Gonadal en Laboratorio de Camaron *Penaeus paulensis* en Uruguay, 1986, and R. Mazzoni, "Informe sobre la Explotación y Cultivo de Camarones *Peneidos* en Uruguay," *INAPE Informe Técnico*, 1986.

10. Spinetti, *op. cit.*

11. "Exitosa Experiencia del Cultivo de Bagre Negro," *El Dia*, August 27, 1982 and "Cria de Camarones," *El Dia*, September 6, 1982.

12. L. Galli, "Estudio Preliminar de la Produccion de *Macrobrachium borelli* (Nobili, 1896) en estanques de tierra," *IV Congreso Nacional de Veterinaria*, 1987.

13. Spinetti, *op. cit.*

14. Spinetti, *op. cit.*

15. "Cria de Camaron de Agua Dulce," *El Dia,* May 5, 1985, and "Mariscos Baratos: Fue Exitoso El Ensayo Realizado Para la Cria de Camarones de Agua Dulce" *El Pais*, May 6, 1985.

16. Gabriel Rodriguez Marquez, personal communications, June 27, 1988.

17. Spinetti, *op. cit.*

APPENDICES

Appendix A.--Addresses

Lic. Mónica Spinetti
Instituto Nacional de Pesca
Casilla de Correo 1612
11200 Montevideo
Uruguay
FAX: 5982-413216

Appendix B.--Uruguay. Shrimp species

Scientific	Species: English*	Species: Spanish*
Marine		
Artemesia longinares	Argentine stiletto	Estilete argentino/argentino
Penaeus	Penaeids	Penidios
brasiliensis**	Red/pink spotted	Rosado con manchas/rosa
paulensis	São Paulo	São Paulo/pardo
Pleoticus muelleri***	Argentine red	Langostin argentino/langostino rojo
Freshwater		
Macrobrachium borelli	NA	NA
Palaemonetes argentinus	NA	NA
Pseudopalaemon bouvieri	NA	NA

* FAO terms, commonly used Uruguayan names after slash in Spanish column.
** Until 1967 often reported as P. aztecus.
*** Previously referred to as Hymenopenaeus muelleri
Source: FAO. "Shrimps and Prawns of the World" FAO Species Catalogue, Vol. I, Rome, 1980 and Spinetti, op. cit.

4.13

VENEZUELA

Venezuela's shrimp industry is dominated by its trawler fleet, which caught more than 8,600 metric tons of shrimp in 1989. In comparison, the shrimp culture industry harvests only small quantities. Various groups have been attempting to culture shrimp in Venezuela for several years. Growers have increased harvests each year since 1985. Particularly important increases were repeated in both 1990 and 1991. The Government reported a 1991 harvest of nearly 600 tons, but some industry sources suggest that the harvest was about 800 tons. Despite the limited results achieved, during the 1980s, considerable interest exists in the industry and continued increases are likely during the 1990s.

CONTENTS

I. AREA

The potential area suitable for development is unknown. One observer reports that more than 10,000 ha could be developed, mostly on the western coast in Zulia and Falcon states.[1] Other observers, however, report that Venezuela does not seem to have an extensive area of suitable sites. Extensive coastal stretches are arid. Along much of the coast the mountains fall precipitously to the sea, leaving only limited level areas suitable for pond construction.[2]

Growers had built about 500 ha of marine shrimp ponds by 1990 (appendix B). A 1992 report indicated that growers had built 570 ha of ponds, almost all of which were in use.[3] The current farms have plans to expand to about 1,200 hectares.

II. FARMS

There are five operating marine shrimp farms, two relatively large commercial farms and three smaller operations. Two farms are located east of Caracas. These are: **Aquamarina de la Costa** (210 ha) in Anzoátegui[4] and **Aquacam** (50 ha)[5] in Sucre. Two small farms are located in the western state of Zulia, **Bioindustrias Venezolanas** (35 ha) and **Sagua** (30 ha).[6] One farm is located on the central coast in the state of Falcón, **Ricoa Agromarina** (200 ha),[7] which is owned by Protinal, one of Venezuela's largest feed companies.[8] Observers expect about 200 ha of addition shrimp ponds will become active in 1991-92.[9] A new farm in Anzoátegui, **Siembra Marina** (140 ha), will reportedly begin production in late 1991. The farm is owned by Maveza, another large Venezuelan feed company.[10] Three farms are reportedly cooperating in the construction of a modern new processing plant to be completed in 1993.

Figure 1.-- Map of Venezuela.

Photo 1.--Venezuela. Aquacam has built about 50ha of ponds near Cumaná. © *Jorge Pang, Agromarina*

III. METHODS/YIELDS

Venezuelan growers primarily employ semi-intensive methods. Growers had been reporting relatively low yields compared to those achieved at semi-intensive farms in other Latin American countries. Growers are now reporting substantial improvements. The industry average is 1.1-1.4 t per crop, and growers are reporting about 2.3 crops per year. This means annual yields of 2.5 - 3.2 tons. Production costs are still relatively high, however, about $3.20 per kilogram. As the growers receive about $3.30 per kg, most are operating at about the break-even point. As a result they have been unable to expand sufficiently to gain significant economies of scale.[11]

IV. SPECIES/POSTLARVAE SUPPLIES

Growers currently culture both marine and freshwater shrimp:

Marine: Growers primarily culture *Penaeus vannamei* as well as small amounts of *P. stylirostris* and *P. schmitti*. Farmers have also experimented with *P. japonicus* and *P. monodon*. Farmers have not yet determined the species best suited for local conditions. *P. vannamei* and *P. stylirostris* are not native to Venezuelan waters; thus, Venezuelan growers are dependent on hatchery produced postlarvae (pl), either domestic or imported. Three farms, Aquamarina de la Costa, Aquacam, and Ricoa Agromarina, have hatcheries (appendix C). Pl production averaged over 20 million per month in 1990. Another farm, Sagua, is reportedly constructing a hatchery.[12] Importing pl is a complicated process. The Venezuelan Government requires that imported pl, which comes mostly from hatcheries in Panama and Colombia, be kept in quarantine for at least 30 days.[13] Some reports indicate that this has resulted in low pl survival rates, substantially increasing costs for Venezuelan growers.[14] Current research also suggests it affects pl quality. One observer reports that the Government may modify this policy.[15] A lack of agreement among growers on the appropriate species for local conditions has complicated efforts to develop the hatchery industry. A consensus would have allowed the hatcheries to focus on one species. A small amount of *P. schmitti* is cultured from pl collected off Venezuela. The Government requires a permit to capture postlarvae.

Freshwater: Three companies are reportedly culturing freshwater shrimp *(Macrobrachium rosenbergii)*. Farms include: **Acuafin** (Falcon), **Aquacria Maruria** (Carabobo), and **Agricultura Zuliana** (Zulia).[16] Acuafin operates a 150-ha shrimp and red tilapia

Photo 2.--Venezuela. This farm in the eastern area of the country is using P. vannamei. © *David Larson*

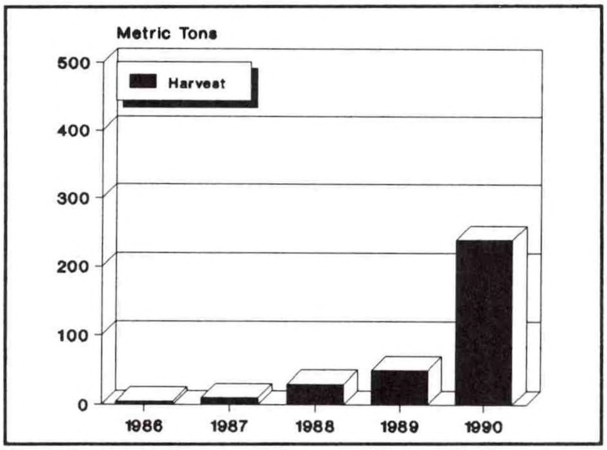

Figure 1.--Venezuela. Cultured shrimp harvest 1986-90.

farm and hatchery consisting of twelve 2-ha ponds and 20 smaller ponds. Harvests of 160 tons (t) of tilapia and 20 t of shrimp were reported for 1990. About 70 percent of this is exported.[17] No information is available on the other freshwater operations.

V. HARVESTS

Venezuelan shrimp growers have been reporting small harvests since 1986. Growers have reported increases each year, but by 1989 were still only harvesting about 70 t per year. Some farms are now beginning to report substantial harvests. The Government reported a major increase in both 1990 and 1991, harvesting a record 260 t and 580 t respectively (appendix D). The harvest is primarily marine shrimp, but small amounts of freshwater shrimp are also reported. The Government assessments may understate the progress being made. Industry sources report a 1991 harvest of as much as 800 tons.[18]

VI. GOVERNMENT POLICY

Industry observers report that a complicated bureaucratic process requiring the coordination of different Government ministries as well as stringent environmental regulations[19] have slowed the industry's development. The Government regulates the industry through the control of operating permits. Reportedly, a number of farms are waiting for Government authorization to begin operating. Only 5 out of 30 farms, which have registered for permits, are operating.[20]

The Ministry of the Environment (MARNR) is concerned about the potential impact of the industry and identified it as an activity which could be "harmful to the environment." This determination is based primarily on the Ecuadorean experience where large estuarine areas with mangrove forestry were cut. MARNR also requires regular analysis of pond effluent.[21] Officials are also concerned about the impact of importing exotic species.

The Ministry of Agriculture has offered some support. The Government has initiated a "National Plan for Aquaculture (1990-93)" in an effort to promote the industry. The Government is attempting to attract foreign capital and technology to stimulate the development of export industries such as shrimp farming. While the Government has no fiscal incentive for aquaculture, it has lifted import/export restrictions, eased laws regulating foreign ownership and profit repatriation, and abolished fixed rate currency transactions.[22] It is unclear, however, if these changes will have any significant impact on the industry's development. The Government is also considering some fiscal incentives, such as allowing growers to apply for special 10 percent export rebates.

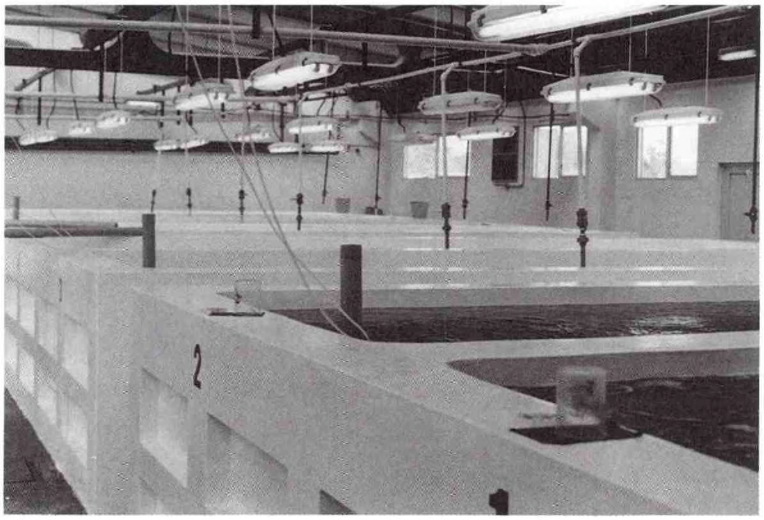

Photo 3.--Venezuela. The Ricoa Agromarina farm in Falcon state has 200 ha of growout ponds and a hatchery. © Jorge Pang, Agromarina

VII. FOREIGN ROLE

The industry has been developed primarily with national capital and expertise. No foreign assistance programs are active. One U.S. consulting firm (Tropical Marine Technology), however, is providing technical assistance to two of the important farms.

VIII. OUTLOOK

The potential to culture shrimp in Venezuela is unknown at this point. According to one industry source, the country has several advantages, including tropical climate, lower construction costs compared to other countries in the region, and excellent infrastructure.[23] Another advantage is fuel prices which are much lower than in other countries. Harvests should continue to grow, as existing farms expand and new farms are constructed, but the industry's expansion may proceed slowly. High wages and strict environmental regulations are slowing development. Projections are difficult, without more accurate estimates on potential farm sites, but harvests by 2000 should reach 2,000-3,000 tons.

This report was originally prepared by Tom Revord and Dennis Weidner and published as IFR-91/77 on September 20, 1991 and subsequently revised on September 2, 1992.

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Zambrano, Jesus. Ricoa Agromarina, personal communications, May 15, 1991.

ENDNOTES

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1. Jesus Zambrano, Ricoa Agromarina, personal communications, May 15, 1991.

2. Ron Staha, *World Shrimp Farming*, May 1990.

3. U.S. Embassy, Caracas, July 31, 1992.

SECTION II (Farms)

4. John Davidescu, Aquamarina de la Costa, personal communications, May 6, 1991.

5. Harvey Persyh, *Tropical Mariculture Technology*, personal communications, October 1990.

6. Francisco Herrera Teran, Director General, Sectorial de Pesca y Acuicultura, personal communications, April 30, 1991.

7. Zambrano, personal communications, *op. cit.*

8. Staha, *op. cit.*

9. Herrera Teran, personal communications, *op. cit.*

10. Davidescu, personal communications, *op. cit.*

SECTION III (Methods/Yields)

11. U.S. Embassy, Caracas, July 31, 1992.

SECTION IV (Species/Postlarvae Supplies)

12. Herrera Teran, personal communications, *op. cit.*

13. Dennis Weidner, "Venezuelan Marine Shrimp Culture" International Fishery Report (IFR-85-41), August 19, 1985.

14. U.S. Embassy, Caracas, October 24, 1990.

15. Zambrano, personal communications, *op. cit.*

16. U.S. Embassy, Caracas, August 30, 1991.

17. Eduardo Mata, Acuafin, personal communications, May 2, 1991.

SECTION V (Harvests)

18. U.S. Embassy, Caracas, July 31, 1992.

SECTION VI (Government Policy)

19. All fish farms must submit an environmental impact study prior to their establishment. Authorization is issued by the Ministry of Environment and Renewable Natural Resources (MARNR). "A Preliminary Review of Selected Legislation Governing Aquaculture," FAO, UN Development Program, 1989.

20. Herrera Teran, personal communications, *op. cit.*

21. U.S. Embassy, Caracas, July 31, 1992.

22. Staha, *op. cit.*

SECTION VIII (Outlook)

23. Staha, *op. cit.*

APPENDICES

Appendix A. -- Venezuela. Addresses.

Government Agency

Ministerio de Agricultura y Cria
Direccion General Sectorial de
Pesca y Acuicultura
Torre Norte, Piso 9
Centro Simon Bolivar, El Silencio
Caracas, Venezuela

Farms

Acuicultura Zuliana (SAGUA)
Calle 68 entre Av. 21 y 22
Centro Comercial Uracoa, Local 6
Maracaibo, Venezuela
Telephone: 58-61-520247

Aquamarina de la Costa
Apartado Postal 62583, Chacao 1060
Caracas, Venezuela
Telephone: 58-2-263-2922
FAX: 58-2-333086

Aquacam
Apartado Postal 61058
Caracas, Venezuela
Telephone: 58-2-285-1655
FAX: 58-2-283-3655

Bioindustrias Venezolanas
Apartado Postal 509
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Ricoa Agromarina
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Appendix B.--Venezuela. Principal shrimp farms, 1990.

Farm	Pond Area
	Hectares
Aquamarina de la Costa	210
Aquacam	40
Bioindustrias Venezolanas	35
Ricoa Agromarina	200
Sagua	30
Total	515

Source: John Davidescu, Aquamarina de la Costa, personal communications, May 6, 1991. Lic. Francisco Herrera Teran, Director General, Direccion Sectorial de Pesca y Acuicultura, personal communications, April 30, 1991.

Appendix C. -- Venezuela. Marine shrimp hatcheries, 1990.

Company	Capacity	Species	State
	Millions pl per month		
Aquamarina de la Costa*	6	Pv,Ps,	AZ
Aquacam	7	Pv,Ps,Pst	SC
Ricoa Agromarina*	9	Pv,Ps,	CB
Total	22		

*Hatcheries include broodstock and maturation facilities.
Key: Species: Pv - *P. vannamei*; Ps - *P. schmitti*; Pst - *P. stylirostris*; Pj - *P. japonicus*. State: AZ - Anzoátegui; SC - Sucre; CB - Carabobo.
Source: US Embassy, Caracas, August 1990. John Davidescu, Aquamarina de las Costa, personal communications, May 6, 1991. Lic. Francisco Herrera Teran, Director General, Direccion Sectorial de Pesca y Acuicultura, personal communications, April 30, 1991. Jesus Zambrano, Ricoa Agromarina, personal communications, May 15, 1991.

Appendix D. -- Venezuela. Cultured shrimp harvest, 1985-91.

Year	Quantity		
	Marine	Freshwater	Total
	Metric tons*		
1985	Negl.	Negl.	Negl.
1986	NA	NA	Negl.*
1987	NA	NA	Negl.*
1988	0.5	0.5	1.0
1989	51.0	16.0	67.0
1990	237.0	23.0	260.0
1991	551.0**	31.0	582.0

* some reports suggest harvests of 5-10 tons
** industry sources estimate a 1991 harvest of about 800 tons.
Source: U.S. Embassy, Caracas, July 31, 1992.