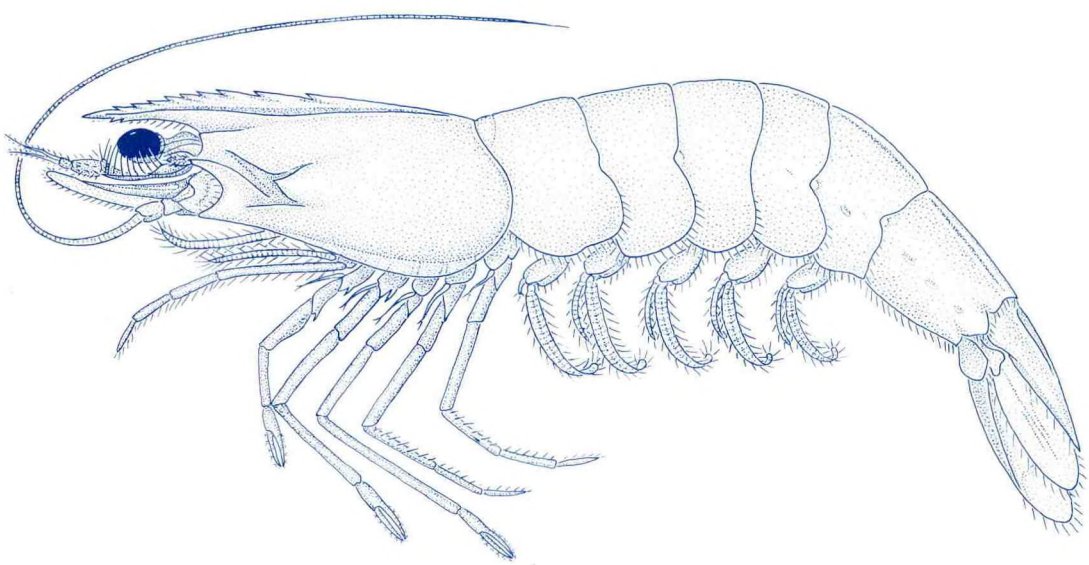
World Shrimp Culture

Volume 1



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World Shrimp Culture

Volume 1: Africa, Asia, Europe, Middle East, North America

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Shrimp Culture. Volume 1.

PREFACE

The National Marine Fisheries Service (NMFS) Office of International Affairs (F/IA) began monitoring world shrimp culture developments in 1983 as part of an effort to both assess the potential economic impact on the important U.S. commercial trawl fishery and to provide basic information to U.S. companies and academic researchers. The shrimp **trawl fishery** is one of the most important U.S. commercial fisheries. Shrimp landings exceeded $0.5 billion in 1991 and play a key role especially in many Gulf of Mexico coastal communities. The massive increases in cultured shrimp harvests during the 1980s have had a major impact on world shrimp markets. The increases have played a major role in the decline of real (inflation adjusted) prices for shrimp. This book and previous assessments are an effort to provide the fishing community sufficient information to understand past trends and make economic projections based on likely future prospects for cultured harvests.

The authors stress that this is not a scientific paper. It is an effort to provide a timely synthesis of available commercial, economic, scientific, and technical information. The authors decided that the time involved in preparing an adequately evaluated scientific paper would mean that the economic and commercial data in the report would be so dated that it would be of little use to interested U.S. companies. Further delays would serious impair the utility of the other reports. The authors have thus chosen to provide a "snap shot" of the industry. A wide range of sources have been used to provide the reader an idea of the full range of data, opinions, and projections available on this rapidly developing industry.

ACKNOWLEDGEMENTS

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The authors are indebted to a much longer list of individuals for information and guidance. One individual, Bob Rosenberry, the indefatigable editor of *World Shrimp Culture*, has been especially helpful, both for his timely publications as well as insightful guidance. Other individuals providing information and publications are too numerous to mention, but their contributions are noted in the sources of each report. U.S. diplomatic posts in many countries were particularly helpful in supplying current information. The authors are most grateful for the cooperation of all those individuals who have so generously provided information and advice. The authors especially appreciate the many individuals who have generously provided photographs to help illustrate the book.

1

WORLD OVERVIEW

The world shrimp culture industry is well developed and competitive especially in terms of international trade. Shrimp farming has existed for centuries, but harvests were relatively low until the mid-1980s. Cultured harvests made up only 6 percent of total shrimp production in 1980, but, thanks to advances in harvesting technology, that figure increased to 26 percent in 1990 (appendix A). An estimated 80 percent of cultured harvests enter global rather than domestic markets. Shrimp culture is almost entirely restricted to two groups of shrimp: the giant freshwater prawn *Macrobrachium* and several species of marine shrimp of the genus *Penaeus*. *Macrobrachium* rearing technology was developed in Malaysia in the early 1960s, but interest waned during the 1980s as penaeid shrimp technology developed and made marine shrimp the preferred species. Penaeid culture began in Japan over 50 years ago and spread rapidly throughout Southeast Asia. Shrimp farmers harvested an all-time high of 699,000 t in 1991 (appendix B), a 7 percent increase over 1990 harvests. Shrimp culture will probably continue to expand during the 1990s, but at a reduced pace.

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I. REGIONAL OVERVIEW

Significant quantities of shrimp are currently cultured in only two regions: Asia and Latin America. Ecuador led world producers until 1984, when climatic events in Ecuador adversely affected harvests and China began reporting major harvest increases. Harvest data for China and Southeast Asian countries are in some cases rough estimates, but clearly large quantities of shrimp are being harvested. While precise data are not available, it is certain that Asian shrimp culture operations expanded more rapidly than their Latin American counterparts during the mid-1980s.[1] Seven Asian countries (China, Indonesia, Thailand, India, Vietnam, the Philippines, and Taiwan) have become major harvesters (appendix B). The potential still exists for expanding harvests in those countries as well as several other countries (Bangladesh, Burma, and Malaysia). Shrimp is also cultured in Africa, Europe, the Middle East, and North America, but harvests in these areas are limited and are not likely to be statistically significant even by the year 2000.

AFRICA

African countries have a significant potential to culture shrimp. Projects are already underway in

several countries (Cameroon, The Gambia, Ivory Coast, Kenya, Madagascar, Senegal, Seychelles, and Zambia). In most countries there are still only one or two small farms. Almost all the important farms are connected with foreign aid programs or investment groups. African governments currently have a limited technical and financial capability to assist the industry. In addition, macroeconomic policies in many countries discourage private sector growth. These factors suggest that while harvests will certainly expand during the 1990s, total output during the 1990s will not begin to realize the region's significant potential. As a result, African harvests are likely to be a very small part of total world production even by the year 2000.

ASIA

The Asian shrimp culture industries have developed rapidly as a result of a combination of factors. Asia has a larger area with a tropical climate suited to pond culture. Many countries have extensive experience in both fisheries and aquaculture. Several governments (e.g. China, Indonesia, and Thailand) carried out significant promotion programs, offering growers both financial and technical assistance. Many governments also implemented macroeconomic policies which were highly favorable to private sector development. The economic climate in many Asian countries has been one of rapid economic expansion during the 1980s, compared to the economic retrenchment experienced in many Latin American countries caused by the debt crisis. The Asian shrimp culture industry has also benefitted from the emergence of a new generation of enterprising business leaders backed by major investments from rapidly growing national companies as well as important multinational companies.

Some observers are now expressing concern, however, over the rapid expansion of the industry as uncontrolled development has resulted in considerable environmental degradation. One Thai expert, for example, compares the methods of some growers to "slash and burn" land use.[2] Several countries have reported increasingly severe disease problems. Only Taiwan has reported a major production failure because of disease, but other incidents are increasingly possible as growers intensify operations. Increasing use of antibiotics and other chemicals is causing concern in Japan and other major importing countries.[3] Growers in several countries are reportedly having increasing difficulty marketing their expanding harvests.

Asian countries that shipped only small quantities of shrimp to the United States in the 1970s became the major suppliers during the 1980s. The ability to further expand sales on the U.S. market is unclear. Asian shipments to the United States were relatively unchanged in 1991; Thailand increased shipments, but China's shipments declined. Several other Asian countries reported small increases. Asian growers have expanded harvests only 20 percent since 1987 and less than 10 percent since 1988. Three important producers (China, the Philippines, and Taiwan) have actually reported production declines since 1987 (appendix B). The Chinese decline was particularly significant because of the quantities involved. These trends suggest that the industry's expansion in Asia may moderate during the 1990s.

Some observers, however, are more optimistic about the future of Asian shrimp culture. Technological advances may help resolve some current problems. Growers have gained considerable experience and the level of technical competence is rising. Some potential market developments are promising. The European shrimp market is expanding and several Asian countries are participating in that expansion. Other countries besides the major three importers (Japan, the U.S., and the EC) are also increasing imports and collectively probably account for about 150,000 t of shrimp imports. The economic success of several Asian countries (especially Hong Kong, Singapore, Taiwan, Korea, and Thailand) may help expand domestic shrimp consumption. If consumption increases significantly, it could help stabilize shrimp prices and have a major impact on the expansion plans of Asian growers.

The Oceania region has a somewhat small potential production area. The Pacific Island countries have very small areas that are suitable for pond culture. The only important exception is Australia which could develop an important shrimp culture industry along its northern and northeastern coast. Shrimp culture operations elsewhere in Oceania are limited, although the French are active in New Caledonia.

EUROPE

European production is limited as climatic conditions are not appropriate in most of the continent for extensive and semi-intensive operations. Some semi-intensive farms could be built in southern Europe (Greece, Italy, Spain, and Portugal) where climatic conditions are most favorable. Growers in

these temperate climates, however, will probably have difficulty competing with low-cost Asian and Latin American growers enjoying tropical growing conditions. Several countries have sophisticated fishery research infrastructures (France, Germany, Norway, Spain, and the United Kingdom) that support developing aquaculture industries.

Eastern European countries and Russia have no crustacean farms, primarily because of inappropriate climatic conditions. At least two countries, however, report some preliminary research. Romania is studying the culture of crayfish along its Black Sea Coast and Hungarian researchers are studying the potential of geothermal ponds for freshwater shrimp culture.

LATIN AMERICA

The Latin American shrimp culture industry lags far behind the emerging industry in Asia. The 140,000 t of shrimp cultured by Latin Americans in 1991 was only about 20 percent of the total world cultured harvest (appendix B). The Latin American share of the total world harvest of cultured shrimp increased slightly in the late 1980s and early 1990s as the rate of expansion slowed in Asia. Latin American harvests increased nearly 70 percent between 1987-91, compared to only 20 percent for Asian harvests. The Latin American share will probably continue expanding in the 1990s as several important potential producers begin significant harvests. Developments in Mexico, Colombia, Brazil, and Central America, will have an especially important impact on the industry's future. The Latin American share could significantly increase if growers are able to initiate commercial operations successfully along the Atlantic/Caribbean coasts. Such operations are currently limited primarily to Colombia's Caribbean coast.

The ability of Latin American growers to continue expanding will be determined by a wide range of unquantifiable variables. One key factor that will affect future expansion will be their success in acquiring and utilizing modern technology to improve yields while avoiding the potentially serious pond management problems associated with higher yields that Asian growers have experienced. Shrimp prices and market fluctuations will have a powerful impact on growers, because further price declines would reduce profit margins and the financial ability of growers to acquire needed technology.

MIDDLE EAST

The Middle East has a relatively small aquaculture industry. Countries such as Iran, Iraq, and Israel have developed their aquaculture industries by farming freshwater species (primarily carp). Shrimp culture in the region is still in its infancy. Natural conditions such as water salinity and extreme temperature swings are not favorable to shrimp culture development. In addition, Muslims and Orthodox Jews do not eat shellfish, a fact which nearly eliminates the hope of supplying domestic markets. The possibility for successful shrimp culture development exists in this region, but it will be an uphill struggle.

NORTH AMERICA

North American shrimp culture is limited to the United States.[4] U.S. growers have demonstrated that they can culture shrimp, but most growers are having difficulty competing with low-cost product from tropical countries. Some growers, however, are optimistic, and considerable research has been conducted by growers, consulting, and university groups. Some of the key research work which supports Latin American shrimp culture was conducted in the United States. U.S. growers reported only small harvests during the 1980s, but the quantities are gradually increasing and should continue to increase during the 1990s.

Some success with intensive culture has been reported in **Hawaii**, but harvest quantities are still limited.[5] Semi-intensive operations have been conducted in several states. The most sustained trials have been conducted in **Texas**.[6] Texas A&M and state researchers have also made a major contribution to shrimp culture methods. Growers in the state, however, continue to report a variety of difficulties. The primary limiting factor has proven to be climatic, with growers unable to achieve two crops in semi-intensive systems. Growers are also active in **South Carolina**.[7] Several small farms are currently reporting limited success supplying high-priced fresh and live product. The South Carolina growers are also limited by climatic factors, but continue to aggressively pursue alternative growout methods assisted by a state-supported research program.

II. OUTLOOK

Shrimp culture will probably continue to expand in the 1990s but at a reduced pace. Many of the major Asian producers seem to have reached peak harvest levels, and China's harvest actually decreased in 1991. Other Asian producers continue to expand, but face significant constraints in terms of expertise, pollution, disease, infrastructure, and market fluctuations. Farmers in other areas of the world should increase harvests, but also face many of the same constraints. Overall, world shrimp farming faces a period of increased production accompanied by increased competition.

Note to the reader: The NMFS Office of International Affairs follows the development of the world's farmed shrimp industry. The Office neither supports nor opposes the development of shrimp farming. The Office has tried to report on world shrimp culture in a factual and responsible manner. In some reports, brand and company names have been included. **It is not the policy of the U.S. Deparment of Commerce to endorse any product or company**. Likewise, the omission of any product or company is not an indication of disapproval by the U.S. Department of Commerce.

The information on world shrimp culture has been obtained from diverse sources and is difficult to verify. Statistical data have generally been obtained from fishery officials of the various countries (usually through the U.S. Embassy in that country), or United Nations Food and Agriculture Organization (FAO) catch statistics. Anecdotal information has come from international trade and industry publications and personal communications. It is difficult to obtain accurate information on private shrimp farms in any country because of the reluctance of farmers to reveal details of their operations. Nevertheless, it is hoped this report will provide the reader with a useful overview of the industry.

This overview was prepared by Dennis Weidner and Mark Wildman in July 1992.

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ENDNOTES

1. For a good overall survey of developments in Asia and Latin America see Bob Rosenberry, *World Shrimp Farming, 1990*, January 1991. Also see Dennis Weidner and Bob Rosenberry, "World Shrimp Farming," *Proceedings of the Special Session on Shrimp Farming*, World Aquaculture Society Annual Meeting, AQ92, May 22-25, 1992, pp.1-21. Good historical surveys are also available in Imre Csavas, "Shrimp Farming Development in Asia," in *Shrimp '88: Conference Proceedings*, (INFOFISH: Kuala Lumpur, 1988), pp. 63-92 and Paul Niemeier, "The Status of Asian Shrimp Culture," *International Fishery Reports*, (IFR-88/33), April 21, 1988.

2. C. Kwei Lin, Asian Institute of Technology, "Intensive Marine Shrimp Culture in Thailand: Success and Failure," paper delivered at Aquaculture '92, Orlando, Florida, May 24, 1992.

3. For example, see Bob Rosenberry, "Antibiotic Scare in the Philippines," *World Shrimp Farming*, July 1991, pp.14-15.

4. There are no known Canadian research institutes working on shrimp culture. Carolyn Walker, personal communications, July 6, 1992. For organizational simplicity, Mexican, Central American, and Caribbean countries which geographically are part of North America, are included under Latin America.

5. For details, see Gary D. Pruder, "Shrimp Culture in North America and the Caribbean: Hawaii, 1988," *Shrimp Culture in North America and the Caribbean*, edited by Paul Sandifer (World Aquaculture Society: Baton Rouge, Louisiana, 1991), pp. 58-69.

6. For details, see G.W. Chamberlain, "Status of Shrimp Farming in Texas," *Shrimp Culture in North America and the Caribbean*, edited by Paul Sandifer (World Aquaculture Society: Baton Rouge, Louisiana, 1991), pp. 36-57.

7. For details, see J. Stephen Hopkins, "Status and History of Marine and Freshwater Shrimp Farming in South Carolina and Florida," *Shrimp Culture in North America and the Caribbean*, edited by Paul Sandifer (World Aquaculture Society: Baton Rouge, Louisiana, 1991), pp. 17-35.

APPENDICES

Appendix A--World. Total shrimp harvests, 1981-91.

Year	Harvest		Total Harvest	Proportion Cultured
	Capture	Culture		
	1,000 Metric tons*			Percent
1981	NA	NA	1,627	NA
1982	1,653	84	1,737	5
1983	1,684	143	1,827	8
1984	1,746	174	1,920	9
1985	1,925	213	2,138	10
1986	1,927	309	2,236	14
1987	1,821	551	2,372	23
1988	1,902	604	2,506	24
1989	1,869	611	2,480	25
1990	1,875	652	2,527	26
1991	NA	699	NA	NA

* - Live weight equivalent
NA - Not Available
Sources: FAO, Fisheries Statistics Yearbook, various issues (total harvests); Bob Rosenberry, World Shrimp Farming, various issues (cultured harvests).

Appendix B.--World. Estimated cultured shrimp harvests, 1987-91.

Region/ Country	Year					Change 1987-91
	1987	1988	1989	1990	1991	
	1,000 Metric tons*					Percent
Asia						
China	153	199	175	150	145	-5
Indonesia	73	96	97	120	140	92
Thailand	24	56	94	100E	110E	358
India	22	25	25	30	35E	59
Vietnam	20	22	22	30E	30E	50
Philippines	36	45	48	54	30E**	-16
Taiwan	115	44	32	30	30E	-74
Other	23	25	29	35	38	65
Subtotal	466	513	522	549	558	20
Latin America						
Ecuador	69	70	64	70	100	45
Colombia	1	1	3	6	10	900
Mexico	4	6	5	8	9	125
Peru	2	2	4	5	6	200
Honduras	2	2	3	3	5	150
Other	5	8	8	10	9	80
Subtotal	83	89	87	102	139	67
Africa	1	1	1	NA	NA	-
Middle East	Negl	Negl	Negl	Negl	Negl	-
Europe	Negl	Negl	Negl	Negl	Negl	-
North America	1	1	1	1	2	100
Oceania***	NA	NA	NA	NA	NA	NA
World Total	551	604	611	652	699	27

* Liveweight equivalent
** As reported by Rosenberry, World Shrimp Farming op. cit. The authors have no other confirmation of this sharp decline.
*** Included in the Asian totals.
NA - Not Available
Sources: Mark Wildman and Todd Schneider, "Asian Shrimp Culture," International Fishery Reports, in press (Asian Data) and Dennis Weidner, "Latin American Shrimp Culture," International Fishery Reports, in press (Latin American Data).

2

AFRICA

Aquaculture in Africa has significant potential, although the industry is currently underdeveloped. With the exception of Egypt and Nigeria, which farm large quantities of freshwater fish (tilapia, carp, and catfish), the continent's resources have not been fully utilized. Shrimp aquaculture in Africa is a relatively new industry. The first shrimp farming project was established in 1979 in Kenya, and most countries did not begin shrimp aquaculture until the mid or late 1980s. Despite favorable natural conditions such as water salinity and climate, there are only a small number of shrimp farming projects operating in Africa. Limited infrastructure, technical capabilities, and financial resources necessitate the involvement of foreign aid and investment. Shrimp is not cultured in sufficient quantity to enter global markets. Shrimp aquaculture in Africa will no doubt increase in the future as investors take advantage of the favorable natural conditions, and African governments pursue shrimp culture development policies.

CONTENTS

COUNTRY REPORTS

ALGERIA

Algeria produced 2 metric tons (t) of cultured shrimp (*Penaeus kerathurus*) in 1989 (appendix A).[1] The country has a small aquaculture industry, harvesting only 16 t in 1989 (appendix B).

CAMEROON

Cameroon has Africa's largest shrimp fishery. Fishermen caught nearly 13,000 t of shrimp in 1989, about 30 percent of the African total. The primary species are *Palaemonid* and *Penaeus ssp.*

The overall aquaculture industry is very small. Total harvest amounted to only 160 t in 1989. The primary species are tilapia and carp. Cameroon has no known operational commercial shrimp farms. Foreign groups have, however, shown some interest in developing the country's potential. The French consulting firm **Sogreah** reported that the country's first farm, the Industrial Prawn Farm, was built with 140 hectares (ha) of ponds in 1984. The farm had a planned annual harvest of 400 t of shrimp.[2] The

farm does not appear to be currently operating, however, as there was no reported cultured shrimp harvest in Cameroon during 1986-89.[3]

A U.S. company planned and carried out a shrimp culture feasibility study in 1986 for **Socarto**, a Cameroonian firm. The project to be assessed included a hatchery, nursery ponds, growout ponds, and a processing plant. The study was to have been funded in part by a reimbursable grant from the U.S. Trade and Development Program of the U.S. Department of State. Because of a lack of funding, however, the study was never completed, and the project was terminated in March 1987.[4]

Several specialists believe that the potential for shrimp culture in Cameroon is good, among the best in Africa. Not only are climatic conditions appropriate, but there also appear to be many suitable sites. The government would like to promote a shrimp culture industry. The trawler catch of wild shrimp has declined in recent years, and an alternative source is needed to substitute for the decreased export earnings.[5] Cameroon's Fifth and Sixth Five Year Plans (1981-1986; 1986-1991) make provisions for shrimp culture. However, the funds allocated for shrimp and mollusk aquaculture decreased sharply between the two plans from US$3.2 million in 1981 to only US$0.3 million in 1986. The reason for the diminishing government investment in shrimp aquaculture is unknown. According to Dr. Moukia Mbome Gottlieb, the Director of Fisheries at the Ministry of Livestock Fisheries and Animal Industries, the Ministry plans to use the results of ongoing research in Ghana to finalize plans for the promotion of shrimp aquaculture in Cameroon.[6]

CAPE VERDE

Cape Verde currently has no aquaculture industry at all, and no capture shrimp harvest. There are no known commercial or experimental shrimp farms in Cape Verde. Several consulting groups have conducted assessments of Cape Verde conditions. The Water Resources Research Center at the University of Arizona conducted a shrimp culture feasibility study in 1987. In addition, U.S. consultants from the Marine Advisory Service at Texas A & M University, Aquafood Business Associates, and Coastal Science and Engineering have also prepared a shrimp culture feasibility study. The proposed project, which involved both government and private investment,[7] was never finalized.

The suitability of Cape Verde for culturing shrimp is questionable. Some conditions are favorable. Climate and water temperature appear suitable for *Penaeid* culture in Cape Verde. The country is a refueling station for air cargo planes, which would facilitate the delivery of fresh shrimp to Europe and the United States.[8] Other factors are less favorable. The high salinity of coastal water, the lack of fresh water on the islands, the constant strong winds (which would cause erosion of pond walls and swift pond evaporation), and lack of any indigenous broodstock are serious problems. As a result, the country's potential for shrimp culture appears limited.

COTE D'IVOIRE

Côte d'Ivoire[9] (also known as the Ivory Coast) has a relatively modest shrimp fishery. Fishermen caught more that 2,500 t of shrimp in 1989, about 6 percent of the African total. The overall aquaculture production was more that 1,700 t in 1989, mostly tilapia. A subsidiary of the Dutch company **Unilever** operates the country's only shrimp farm.[10] Additional information on the farm's size or harvest are unavailable, but another source reports *P. monodon*, *P. indicus*, and *P. notialis* are being cultured on an experimental basis.[11]

France-Aquaculture conducted a survey in 1983 on the possibilities of shrimp farming in Côte d'Ivoire which found the country had the potential to culture shrimp. The European Economic Community Development Fund and the French Cooperation Fund together with the Government of Côte d'Ivoire financed a feasibility study for a pilot shrimp farm at Assinie-Mafia, about 120 km from Abidjan.[12] The project was to include a hatchery, growout ponds (2 ha), and a small feed plant. It would have produced an annual yield of 4-6 tons[13]. Officials planned to experiment with *Penaeus notialis* and other species.[14] It is unknown whether this project was ever initiated.

EGYPT

Egypt has the most significant aquaculture industry in Africa. Growers report that 50,000 t of freshwater fish were farmed in 1989, which represents more than 60 percent of all aquaculture activity in Africa. Cultured shrimp represents a fraction of Egypt's total shrimp production. Egypt harvested 4 t of shrimp (55 percent freshwater/45 percent marine) in 1991, less than 0.1 percent of Egypt's total shrimp production. The primary species being harvested are *M. rosenbergii*, *P. japonicus*, and *P. semisculatus*.[15]

Egypt has six major shrimp farms, five of which are state-owned. All the state-owned farms cultivate freshwater shrimp. The Government of Egypt is studying several proposals to encourage shrimp culture, primarily by providing incentives to the private sector. The Egyptian aquaculture consulting firm, Arab Aquaculture Consultants Office (AACO), is reportedly building a commercial marine shrimp hatchery and a 40-ha semi-intensive farm at a site on the Gulf of Suez.[16]

THE GAMBIA

The Gambia has a small shrimp fishery. Fishermen caught only 323 t of shrimp in 1989, less than one percent of the African total (appendix A). There is no aquaculture industry apart from shrimp culture.

The Government of The Gambia formed a joint venture to culture shrimp in 1986 with the Norwegian firm **Scanaqua A/S**, a member of the Bartz Group in Bergen. The $11 million joint venture, **Scan Gambia**, Ltd., is 51 percent Norwegian owned and 49 percent owned by Gambian interests. The Scan Gambia farm is a large semi-intensive facility at Pirang on the Gambian River.[17] The farm consists of 54 four-hectare ponds, as well as a reservoir, a hatchery, and a processing plant.[18] Scan Gambia is culturing *P. monodon* and the local *P. notialis*. The company reportedly harvested 53 t of *Penaeid* shrimp in 1989[19] and 124 t in 1990 .[20]

The Directorate General for International Cooperation and the University of Wageningen in the Netherlands also reportedly support a shrimp culture project in The Gambia.[21] Details on this project are not available.

GUINEA

Guinea currently has no aquaculture production nor commercial shrimp farming activity, though small amounts of tilapia had been farmed in the past.

The Government of Guinea, in association with the French company **Sepia International**, constructed a 7-ha marine shrimp farm at Sakoba in the Koba rice-plain region in 1988. The pilot farm was built to develop the feasibility of shrimp-growing prior to committing funds for the development of a 600-ha commercial farm. A hatchery is being constructed on the island of Tamara off the Conakry peninsula.[22] The Government is proceeding with the commercial project which Sakoba Director Pascal Lafaix estimates will produce 2,000 t annually. The farm, which will also include a treatment and freezing plant, is to go into production in 1994. Two thirds of the shrimp basins will be for industrial shrimp farming. The rest will be for artisanal exploitation. Reportedly, the species cultured are *P. vannamei* and *P. notialis*.[23] The African Development Bank approved a $36.7 million loan in September 1991 for the Koba Shrimp Farming Project.[24]

The Secretary of State for Fisheries (SSF) is studying a second shrimp farm project. The SSF has commissioned a study modeled after the Koba pilot farm to investigate the viability of shrimp culture in mangrove zones.[25]

GUINEA BISSAU

Guinea Bissau has no capture shrimp fisheries and no aquaculture industry. One source reports experimental culture studies of *Penaeid* species in Guinea Bissau.[26] The authors, however, have no information confirming such activities.

KENYA

Kenya had a small capture shrimp harvest in 1989. The aquaculture sector, at more than 900 t in 1989, is the seventh most significant in Africa, but still accounts for less than one percent of Africa's entire aquaculture production. Kenya was the leader of African shrimp aquaculture and was for a long time the only African country with functioning, albeit still experimental, growout ponds.

The principle shrimp farming project, The Kenyan Project, was initiated in 1979. The project is supplied by an experimental hatchery in Malindi. The farm has six growout ponds located at Ngomeni, 30 km to the north.

The Malindi hatchery had a capacity of approximately 40,000-50,000 post-larvae (pl) per month as of November 1986. More current data are not available. A variety of species (including *P. indicus*, *P. monodon*, *Macrobrachium lepidactylus*, and *M. rosenbergii*) are being studied. The FAO provided technical assistance until the beginning of 1987, at which time the Government of Kenya was to have assumed control.[27] Current information on the status of the project is unavailable. Kenya reported a small *Penaeid* shrimp harvest of 5 t in 1986, but

harvests ceased by 1989,[28] suggesting the Ngomeni farm may have been closed.

MADAGASCAR

Although there is currently no shrimp fishery in Madagascar, there is a small aquaculture industry in place. The main species farmed is carp. The Government of Madagascar (GOM) planned to establish a shrimp farm along the country's northwest coast in 1988, allocating $0.7 million to develop the farm.[29] The United Nations Development Program (UNDP) financed marine shrimp production, and also financed extension services and training that same year.[30] FAO established a pilot shrimp farm "Ferme pilote d'elevage de crevettes" in May 1989 to demonstrate the feasibility of shrimp culture and to train local biologists and technicians.[31] The farm consists of 3 nursery tanks and 7 ha of growout ponds. Farm managers report harvesting 6 t of shrimp (primarily *P. indicus*) in 1989.

The Madagascar Fisheries Ministry has been working with the U.S. aquaculture firm **Amerorient** and the Japanese fishing company **Taiyo** to develop a $10 million shrimp farm north of the city of Mahajanga in western Madagascar. The United States Trade Development Program (USTDP) is considering funding an impact feasibility study for the project.[32]

MALAWI

Malawi has a small aquaculture industry, harvesting mostly tilapia. Malawi reportedly cultured 6 t of *Macrobrachium sp.* freshwater shrimp in 1989.[33] No further information is available.

MAURITIUS

Mauritius has a small aquaculture industry, over half of which is shrimp production. According to FAO Statistics,[34] Mauritius reportedly cultured 52 t of cultured shrimp in 1989. A United Nations Development Program Survey reports that Mauritius cultures *M. rosenbergii* with some success.[35] The industry has reportedly benefitted from French technical assistance. No further information is available.

MOROCCO

Marine shrimp aquaculture is very new to Morocco, having been introduced in 1992.[36] Two private companies are currently culturing shrimp along the Mediterranean coast of western Morocco. Basins filled with seawater over an area of approximately 100 ha are used to cultivate *P. japonicus*, the primary species cultured. The Ministry of Fisheries estimates harvests will be 25 t in 1992, increasing to 88 t by 1996.

Several government incentives have been provided to promote shrimp aquaculture. Fiscal advantages are found in the National Maritime Investment Code-specifically a 50 percent reduction in corporate income tax and license taxes for the first five years and an exemption from stamp and customs duties on imported equipment. No foreign assistance has been granted for the project, and no foreign joint ventures have been established.

MOZAMBIQUE

Mozambique has an extremely small aquaculture sector, primarily farmed tilapia. The International Center for Living Aquatic Resources Management (ICLARM), reports that Mozambique is cultivating *Penaeus sp.* on an experimental basis.[37]

According to the U.S. Embassy in Maputo, Mozambique's State Secretary for Fisheries and the FAO established a 6 ha farm near Maputo in 1991. The $1.5 million operation was funded by the United Nations Development Program (UNDP). The combined production of marine shrimp in 1991 and 1992 was less than 1 ton. An FAO expert consulted by the U.S. Embassy in Maputo stated that although the site near Maputo is too cold for efficient shrimp production, other sites north of Beira offer ideal conditions for shrimp farming.[38]

NIGERIA

Nigeria has a significant aquaculture industry. The country harvested almost 26,000 t of fish in 1989, primarily tilapia and catfish (appendix B). This represents more than 27 percent of the total aquaculture production for Africa.

Nigeria has a fairly substantial shrimp catch of 3,600 t in 1989. No known commercial shrimp farms exist in Nigeria. A Danish consulting firm coordinated a feasibility study for a marine shrimp farm, but it appears that no farm was actually built. FAO helped fund a freshwater shrimp hatchery at Port Harcourt.[39] The Federal Government, under the auspices of the Niger Delta River Basin

Development Authority in Rivers State, was experimenting with shrimp culture in 1984.[40] Results of the trial runs are unavailable. Due to the abundant supplies of wild shrimp off Nigeria's coast, high capital costs, and problems with the existing aquaculture industry, there are currently no plans to develop a shrimp aquaculture industry in Nigeria.[41]

REUNION

The aquaculture industry in Réunion consists mostly of farming small numbers of green turtles. Réunion cultured 2 t of shrimp (*M. rosenbergii*) in 1989.[42] The French Government research group IFREMER (Institut Français de Recherche pour L'Exploitation de la Mer) has sponsored experimental work with freshwater shrimp.[43] IFREMER introduced the locally consumed species *Macrobrachium lar* to augment the declining wild supply. The present status of this project is unknown.

SENEGAL

Senegal has the second largest capture shrimp fishery in Africa. In 1989, fishermen caught 7,600 t of shrimp, representing 18 percent of the total African harvest. Senegal harvested 3 t of cultured crustacea in 1989.[44] The French and Senegalese Governments sponsored the construction of an experimental shrimp farm and hatchery in Casamanace in 1983. The farm was designed by France-Aquaculture and consists of four growout ponds of 1 ha each, a small hatchery, a pumping station, and a power plant. The farm manager is experimenting with several different kinds of *Penaeid* species, of which *P. monodon* has yielded the best results.[45] The first three years of the experiment from 1983-87 made evident the constraints on local culture, such as the high level of salinity, isolation of the site, and problems with the food supply. The French pulled out of the project in 1987, and Senegal has entirely supported the farm since then with assistance from the parastatal National Agricultural Credit Bank. The projects reported 2 t of shrimp production annually between 1990-92.[46]

SEYCHELLES

The aquaculture industry in the Seychelles consists of a shrimp culture project established in 1989. The Seychelles Marketing Board set up four experimental ponds in 1989, and the ponds produced 7 t of *P. monodon* in 1989.[47] Given the success of the pilot project, the Seychelles Marketing Board established a 5000 square meter farm on the island of Coetivy 200 miles south of Victoria. The $11 million farm consists of 64 growout ponds, a hatchery and a processing plant. Production in 1992 is expected to reach 800 tons.[48]

SOUTH AFRICA

The South African aquaculture industry is the third largest in Africa. The South African Corporation for Economic Development (CED) built a pilot farm the eastern Transvaal during 1983. The farm is culturing *M. rosenbergii*.[49] CED later announced encouraging results, but no current information is available on this project.[50] Recent reports indicate, however, that other serious efforts to culture shrimp are being made. Two companies have recently initiated pilot facilities. The Amatikulu project opened a growout facility in 1990 at Gingindlovu, north of Durban on the east coast. The farm is culturing *P. monodon* and *P. indicus*.[51] Mtunzini Prawn Farm Holdings was established in 1990 just north of Durban.[52] The farm is culturing *P. monodon* and has a small hatchery and growout ponds. Both companies plan to initiate commercial operations within the next 5 years.[53]

TANZANIA

Tanzania has a very small aquaculture industry, producing mostly tilapia. The Norwegian aquaculture company **Scanaqua** reported in 1988 that it was planning a semi-intensive farm for *P. monodon*.[54] Results of that farming project are unknown, but other sources report that small quantities of shrimp are being harvested in experimental facilities.[55]

The U.S. Embassy reports that a group of businessmen have purchased a 5,000 acre farm north of Dar es Salaam and intend to culture freshwater shrimp. This group is presently holding discussions with the Tanzanian Government.[56]

TUNISIA

Unconfirmed reports suggest that growers were cultivating shrimp (*Penaeus sp.)* in Tunisia in 1982.[57] No further information is available, and there is currently no known harvest.

ZIMBABWE

Zimbabwe has a very small aquaculture industry. Growers opened the King Prawn farm at Kariba in 1981. The farm is cultivating *M. rosenbergii* in 30 ha

of growout ponds. The pond manager estimates the capacity to be 60 t per year. Another company, **Aquaprawn**, may also be operating in Kariba. Zimbabwe reportedly harvested an estimated 13 t of cultured shrimp in 1989.[58]

This overview was prepared by Joanne Beverly, Helena Riha, and Mark Wildman between June and August 1992.

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APPENDICES

Appendix A.--Africa. Shrimp harvest, 1989

Country	Production		
	Capture	Culture	Total
	Metric tons		
Algeria	2,644	2	2,646
Benin	7,853	-	7,853
Cameroon	12,994	-	12,994
Côte d'Ivoire	2,585	-	2,585
Eq Guinea	450	-	450
Gambia	270	53	323
Kenya	93	-	93
Malawi	-	6	6
Mauritania	144	-	144
Mauritius	-	52	52
Morocco	33	-	33
Mozambique	160	-	160
Nigeria	3,633	-	3,633
Réunion	36	2	38
Sao Tome & Prin.	23	-	23
Senegal	7,600	3	7,603
Seychelles	-	7	7
Sierra Leone	1,005	-	1,005
South Africa	872	-	872
Togo	26	-	26
Tunisia	2,148	-	2,148
Total	42,569	125	42,694

Sources: FAO, "Aquaculture Production (1986-89)," FAO Fisheries Circular No. 815, Rev. 3, July 1991; and FAO, Fishery Statistics: Catches and Landings, (FAO: Rome, 1991).

Appendix B.--Africa. Cultured fish and shellfish harvests, 1985-89

Country	Year				
	1985	1986	1987	1988	1989
			Metric tons		
Algeria	15	17	17	14	16
Angola	NA	NA	NA	NA	NA
Benin	11	15	14	17	18
Botswana	NA	NA	NA	NA	NA
Burkina Faso	43	40	36	7	6
Burundi	2	21	25	24	25
Cameroon	130	124	137	167	160
Canary Islands	NA	NA	NA	NA	NA
Cape Verde	NA	NA	NA	NA	NA
Cent. Afr. Rep.	288	193	88	79	82
Chad	NA	NA	NA	NA	NA
Comoros Islands	NA	NA	NA	NA	NA
Congo	39	82	115	177	243
Côte d'Ivoire	606	686	847	880	1,720
Djibouti	NA	NA	NA	NA	NA
Egypt	47,346	50,000	51,300	57,100	57,000
Eq Guinea	NA	NA	NA	NA	NA
Ethiopia	NA	NA	NA	1	33
Gabon	2	3	3	2	2
Gambia	NA	NA	NA	NA	53
Ghana	357	359	386	427	430
Guinea	3	1	1	0	0
Guinea-Bissau	NA	NA	NA	NA	NA
Kenya	213	224	210	561	922
Lesotho	23	25	26	30	30
Liberia	8	6	3	2	2
Libya	NA	NA	NA	NA	NA
Madagascar	284	181	194	229	230
Malawi	80	88	103	115	121
Mali	6	10	12	17	13
Mauritania	NA	NA	NA	NA	NA
Mauritius	53	50	72	73	82
Morocco	280	148	154	158	155
Mozambique	NA	5	21	24	24
Namibia	NA	NA	NA	NA	NA
Niger	7	13	19	21	120
Nigeria	7,622	5,456	6,002	10,631	25,840
Réunion	47	73	77	53	40
Rwanda	39	24	55	28	34
Sao Tome & Prin.	NA	NA	NA	NA	NA
Senegal	36	34	34	43	41
Seychelles	NA	NA	NA	NA	7
Sierra Leone	9	14	18	20	20
Somalia	NA	NA	NA	NA	NA
South Africa	214	1,048	1,314	2,832	3,986
Sudan	30	41	43	45	45
Swaziland	12	18	19	20	20
Tanzania	21	32	35	37	40
Togo	30	9	9	5	5
Tunisia	147	182	212	993	950
Uganda	63	35	38	34	35
Zaire	180	689	723	759	760
Zambia	363	695	1 020	1 072	1 070
Zimbabwe	140	140	146	165	163
Total	58,749	60,781	63,528	76,862	94,543

NA - Not available
Sources: FAO, "Aquaculture Production (1986-89)," FAO Fisheries Circular No. 815, Rev. 3, July 1991.

Appendix C.--European Community. Frozen shrimp imports from Africa, 1986-90

Country	Year				
	1986	1987	1988	1989	1990
			Metric tons		
Angola	-	650	6,361	1,506	221
Benin	145	152	-	-	-
Cameroon	529	743	862	1,018	987
Canary Islands	-	875	5,357	2,566	4,422
Congo	-	-	538	203	138
Côte d'Ivoire	452	657	703	653	594
Eq Guinea	-	-	1,196	232	-
Gabon	1,829	2,098	1,828	1,606	1,177
Gambia	423	327	352	492	724
Ghana	-	-	-	168	141
Guinea	-	-	-	-	118
Guinea-Bissau	159	84	430	300	131
Kenya	766	477	268	162	296
Liberia	88	-	-	123	177
Madagascar	940	1,349	1,789	2,178	2,448
Mauritania	505	369	213	-	-
Morocco	94	1,307	1,854	2,872	3,671
Mozambique	1,678	3,063	6,592	3,672	3,228
Nigeria	-	150	399	1,359	2,860
Senegal	6,565	7,030	8,329	6,957	4,943
Sierra Leone	1,052	1,057	1,180	880	708
Tanzania	-	-	525	567	891
Togo	441	535	547	366	220
Tunisia	3,110	3,822	2,717	1,925	1,726
Total	18,776	24,745	42,040	29,805	29,821

Source: EC NIMEXE

Appendix D.--Japan. Shrimp imports from Africa, 1986-91

Country	Year					
	1986	1987	1988	1989	1990	1991
			Metric tons			
Gambia	-	-	-	-	5	-
Kenya	-	-	7	-	-	-
Madagascar	2,970	2,939	3,160	2,788	2,081	2,441
Mozambique	1,835	1,367	1,627	1,443	1,237	1,355
Nigeria	582	520	468	263	278	103
South Africa	33	-	-	-	-	-
Tanzania	113	121	128	76	-	-
Total	5,533	4,947	5,390	4,570	3,601	3,899

Source: Japan Marine Products Importers Association

Appendix E.--United States. Shrimp imports from Africa, 1985-91

Country	Year						
	1985	1986	1987	1988	1989	1990	1991
				Metric tons			
Cameroon	-	-	-	2	-	-	16
Cent. Afr. Rep.	-	-	-	15	-	-	-
Côte d'Ivoire	Negl	-	-	Negl	-	-	-
Egypt	63	-	-	25	-	-	-
Gabon	-	12	-	-	-	20	12
Gambia	-	-	10	-	-	-	-
Ghana	-	-	Negl	2	1	-	3
Kenya	Negl	-	1	-	-	-	1
Liberia	53	-	-	-	1	-	-
Madagascar	-	77	51	15	-	1	6
Malawi	-	-	-	12	-	-	-
Mali	-	-	39	-	-	-	-
Morocco	1	-	9	5	9	1	-
Mozambique	1	-	-	Negl	12	23	39
Namibia	-	1	12	-	-	-	-
Niger	-	54	-	-	-	-	-
Nigeria	21	157	829	1,347	1,294	1,599	1,308
Sao Tome & Prin.	-	-	-	-	Negl	-	-
Senegal	3	-	-	-	-	-	-
Seychelles	-	-	18	-	-	-	-
Sierra Leone	183	18	-	-	-	-	-
South Africa	1	1	-	-	-	-	-
Tanzania	-	3	1	-	-	-	-
Togo	4	-	-	-	-	-	-
Tunisia	44	-	10	-	-	-	-
Total	374	323	980	1,423	1,317	1,644	1,385

Negl - Negligible
Source: U.S. Bureau of the Census

3

ASIA

Asian shrimp farmers harvested an estimated 522,000 metric tons (t) in 1989, over 30 percent of Asia's total shrimp production (appendices A and B). Growth in Asian farmed harvests has been phenomenal in recent years. The actual 1989 harvest was over 2.5 times the 196,000 t projected for the year 1990 by the National Marine Fisheries Service in 1985. Asian nations account for over 80 percent of the total world farmed shrimp harvests. Of these nations, China, Indonesia, Thailand, the Philippines, and Taiwan were the top Asian harvesters of shrimp in 1989. With the exceptions of Indonesia and Thailand, however, the potential for further shrimp culture growth in these countries appears limited. Pollution, disease, overcrowding, and market fluctuations have taken their toll on most major producers in the past several years, and the greatest potential for growth in Asian shrimp culture lies with less-developed countries such as India, Burma, and Bangladesh.

CONTENTS

I. OVERVIEW

Many Asian countries have a suitable climate and large area available for both marine and freshwater shrimp culture. Several indigenous shrimp species are suitable for culturing. Three major shrimp groups are commonly cultured in Asia: marine species belonging to the genera *Penaeus*, and *Metapenaeus*, and freshwater species of the genus *Macrobrachium* (appendix C). The more commonly cultured species are *Penaeus indicus, P. japonicus, P. merguiensis, P. monodon, Metapenaeus ensis,* and *Macrobrachium rosenbergii*. Exact data on the species composition of Asian farmed shrimp harvests are not generally available, but the National Marine Fisheries Service believes that the two most important species in Asia are *P. monodon*, which dominates the industry in Southeast Asia, and *P. chinensis*, which is the primary species in China.

Shrimp farmers employ three primary methods: **extensive**, **semi-intensive**, and **intensive**.

Extensive shrimp farming is the most prevalent method used in developing countries of Southeast and South Asia because it requires relatively simple

technology and low capital investment. Many extensive shrimp farms in Asia involve the polyculture of several fish species (e.g. milkfish and carp) in ponds, since little additional capital investment is necessary to culture shrimp in an existing pond. Rice paddy/fish culture is utilized in a few Asian countries, but the use of pesticides on rice plants has caused a decline in this practice.

The use of **semi-intensive** farming methods to increase yields is used by many Asian farmers. Semi-intensive farmers use nurseries, grow-out ponds, feeding, and water exchange equipment in their operations. Juvenile shrimp are stocked at high densities in nursery ponds until they are large enough to be stocked at lower densities in growout ponds. This method is used extensively in China, and is being used more and more in Thailand and Indonesia.

Developed and used primarily in Taiwan and Japan, **intensive** shrimp farming involves far greater production costs because the shrimp are carefully monocultured using sophisticated technology. Many Asian countries, while producing enough pl for extensive farming, cannot yet meet the year-round pl supply requirements of intensive and semi-intensive shrimp farming. The artificial nature of this method also makes it prone to disease (e.g. Taiwan in 1988).

The potential for increased foreign exchange earnings is the primary motivation for the rapid development of Asian shrimp culture. Although Asia's wild shrimp stocks once fulfilled export needs, many now show signs of over-exploitation: catch per unit of fishing effort and the average size of wild-caught shrimp are declining in most countries. Because of the lucrative nature of the shrimp industry, it is unlikely that these wild stocks will ever be effectively managed. Shrimp culture, on the other hand, represents a renewable resource which commands high prices and profit margins. As a result, many Asian governments have initiated programs to promote their domestic shrimp culture industries.

The world shrimp market is not infinite, however, and oversupply has already occurred when major consumers, such as Japan, have reduced their demand. Rapid advances in shrimp culture technology (and the consequent increase in yields) may make oversupply a chronic problem as low-yield countries intensify their shrimp culture efforts. Recession in the primary markets of the United States and Japan only intensifies this problem as consumers in these countries reduce their purchases of expensive food products such as shrimp.

Increased harvests could result in significantly lower prices even without a recession. The World Bank's 1989 study on shrimp culture in Southeast Asia predicted the future price of shrimp in light of current harvest trends. The study suggested that by 1993, prices for *P. monodon* from Southeast Asia could be as low as $4 per kilogram for 30-gram heads-on shrimp, compared to a 1988 price of over $6 per kilogram. *P. chinensis* 20-gram shrimp could sell for as little as $2 per kilogram in 1993, down from $3 in 1988.

As a result of lower prices, investment in new shrimp culture ponds would likely slow as profit margins are squeezed. Intensive farmers would have to concentrate on reducing their considerable production costs. Extensive farmers would likely continue to make profits and thereby have incentive to increase yields through modest investments. The shrimp culture industries in India, Burma, and Bangladesh would thus be able to survive a period of low shrimp prices better than the more intensive industries in China, Thailand, and Taiwan.

II. COUNTRY REPORTS

AUSTRALIA

Cultured shrimp harvests in Australia are small (about 1,100 t in 1991-appendix D), but interest in the potential of the industry is growing. Compared to countries in East and Southeast Asia, the shrimp farming industry in Australia has been relatively slow to develop. Despite several earlier attempts, commercial shrimp harvests did not begin until the mid-1980s. There has been considerable development of the industry since that time, particularly in Queensland and northern New South Wales. The recent surge of interest in shrimp culture has accompanied the introduction of new species and cultivation technology. Although shrimp harvests rose sharply in 1989, shrimp culture in Australia is still far from being a viable industry.

In **Queensland**, shrimp harvest increased from 115 t in 1988 to 424 t in 1989. This represented roughly 75 percent of Australia's total farmed shrimp harvest. There are approximately 250 hectares (ha) available in Queensland for shrimp farming. The

number of farms harvesting shrimp increased from 18 in 1988 to 23 in 1989, and the yield also increased. Only two farms produced more than 10 t in 1988, whereas eleven farms exceeded that level of harvest in 1989. Surveys conducted by the Queensland Department of Primary Industries also indicated there has been a change in the species being cultured. Several different species of shrimp were being farmed in 1988, but *P. monodon* comprised 98 percent of the 1989 harvest.

There are seven hatcheries operating in Queensland, which produced approximately 94 million pl in 1989. As the leading territory in Australian shrimp culture, Queensland is also home to two shrimp culture research laboratories: Cleveland Marine Laboratories, and the Bribie Island Aquaculture Center. These two laboratories carry out research on the following topics: maturation, larval biology, cryobiology, hybridization, nutrition, and pond growout.

New South Wales is Australia's second largest shrimp harvesting region, accounting for 170 t or roughly 25 percent of total farmed shrimp in 1989. Approximately 160 ha are currently used for shrimp culture in New South Wales, although this figure represents less than half of the 450 ha approved for shrimp culture by the Australian Government. There were 7 shrimp farms operating in New South Wales in 1989, but this number is expected to increase as more pond area allocated for shrimp culture is brought under cultivation.

The **Northern Territory** is the lowest shrimp harvesting region (1 t in 1989). The Northern Territory had only 1 shrimp farm and 31 ha under cultivation in 1989.

Shrimp harvests in Australia are expected to increase. Queensland should remain the major harvester, followed by New South Wales, and the Northern Territory. Given the warm dry areas where much of the shrimp farming takes place, prospects are good for increased harvests of *P. plebejus*, *P. esculentus*, *P. semisulacatus*, and *P. latisulactus*. The main effort, however, will continue to concentrate on *P. monodon*, which is considered the best species because it is easily cultured and popular in the Japanese market.

Australia does, however, have a number of limitations working against its development as a major shrimp culturing nation. Among these are the country's relative isolation, high cost of labor, Government restrictions on coastal land usage, and a lack of aquaculture infrastructure. Moreover, as with U.S. shrimp fishermen, Australian shrimpers view shrimp culture in a competitive light.

BANGLADESH

Shrimp culture is a mainstay of the Bangladesh export sector -- on average constituting 7 percent of total export earnings. Bangladesh's total 1990 shrimp harvest was an estimated 23,000 t, 87 percent of which was cultured (appendix E). This extremely high percentage of cultured shrimp is the result of a dramatic drop in Bangladesh's wild marine shrimp catch.

Although Bangladesh has an ample supply of cheap labor, other factors such as poor management, lack of infrastructure (especially transportation), and the unavailability of suitable land, quality feeds, and fertilizers continue to hinder harvests. Bangladesh's variable weather conditions also make consistent annual harvests difficult.

A recent example of variable weather conditions was the April 1991 cyclone which swept through the Bay of Bengal and nearly destroyed the shrimp culture region of Chittagong. The Bay of Bengal Programme estimates that the cyclone caused a 4,000 ton loss of cultured shrimp, at a value of approximately $20 million. Since other major shrimp culture areas were unaffected by the cyclone, however, the Government of Bangladesh predicts that the industry will recover quickly.

Bangladesh shrimp farmers primarily culture the following five marine species: *P. monodon*, *P. merguiensis*, *P. semisulcatus*, *P. indicus*, and *Metapenaeus brevicornis*. *P. monodon* and *P. merguiensis* are the two dominant species, accounting for 60 percent and 20 percent, respectively, of Bangladesh's total harvests. *Macrobrachium rosenbergii*, is the most valuable freshwater species cultured in Bangladesh.

Total area devoted to shrimp cultivation is estimated at 240,000 ha, evenly divided between fresh and marine ponds. This represents a dramatic increase from the 20,000 ha of shrimp culture area in 1980. Unlike more advanced competitors in Thailand and Taiwan, however, farmers in Bangladesh have not yet made a sweeping transition to intensive methods.

Roughly 90 percent of Bangladesh shrimp farms utilize low-cost extensive shrimp culture systems.

Despite the dominance of extensive methods, some Bangladesh farmers are beginning to utilize semi-intensive techniques. The species and methods used vary by season and rainfall, as heavy monsoon rains and flooding lower the salinity levels in ponds during the rainy season (May-December). Farmers rely on tidal flows for water exchange in all shrimp culture areas and there is virtually no use of pumps. Although most seedstock arrives with the incoming tide, farmers have learned that stocking *P. monodon* pl can be highly profitable. Stocking rates remain low (typically 10,000-30,000 pl per hectare), and most farmers do not provide supplemental feed.

Average annual yields (about 0.25 t per hectare) improved in the late 1980s, but Bangladesh shrimp farmers still lag behind other Asian countries. Provided that international shrimp markets remain active, however, yields will likely increase with improved pond management and the use of more intensive and semi-intensive methods.

A number of Government and internationally funded shrimp development projects have been established or are in progress in Bangladesh. The Asian Development Bank (ADB) approved a $60 million aquaculture development project in May 1987 which includes $19.5 million for shrimp culture. The 5-year project includes the construction of about 1,000 ha of new shrimp ponds in four districts (Sathira, Khulna, Bagerhat, and Cox's Bazaar), and the upgrading of approximately 5,000 ha of existing ponds. Ten new hatcheries, each with annual production capacity of 4 million pl, are also planned.

Bangladesh currently has two hatcheries -- a freshwater hatchery in Khulna with an annual capacity of 500,000 pl, and a marine shrimp hatchery located near Cox's Bazaar with an annual capacity of 10 million postlarvae. A French aquaculture consulting company, Aqua Service, which provided technical assistance in constructing these two hatcheries, is currently involved in a $4.2 million World Bank/UNDP project to develop 13,000 ha of new shrimp ponds in Bangladesh. The World Bank estimates that the project will increase annual shrimp harvests by approximately 2,000 tons.

The private sector is also heavily involved in shrimp culture development. The leading companies involved in Bangladesh shrimp culture are Sabinco, Beximco, Meghna Seafoods, Inc., Bay Fishing Company, Ltd., and Lever Brothers Bangladesh, Ltd. Lever Brothers Bangladesh, (a subsidiary of Unilever, U.K.) one of Bangladesh's largest shrimp culture companies, has already established a marine shrimp hatchery, rearing farm, and feed mill in the Cox's Bazaar District.

The Bangladesh Government's industrial policy also encourages shrimp culture joint ventures -- primarily through guaranteeing the expeditious repatriation of profits. In addition, the Government announced in May 1991 that it would lend $55 million to cyclone-affected shrimp farmers.

BURMA

Burma first cultured shrimp in 1984, when 7 t of freshwater shrimp was harvested (appendix E). An estimated 4,030 t of shrimp (primarily marine species) was harvested in 1990. This dramatic increase is the result of a shrimp culture industry promotion program which was begun by the Burmese Government in 1986. Despite the rapid increase in harvests, however, Burma has yet to fully exploit its shrimp culture resources. Burmese farmers cultivated approximately 2,920 ha of shrimp ponds in 1990, a mere fraction of the estimated 100,000 ha suitable for shrimp culture.

Several major shrimp species are cultured in Burma: *Penaeus monodon*, *P. pencillatus*, *P. semisulcatus*, *Metapenaeus affinis*, *Parapenaeus harwickii*, *Macrobrachium rosenbergii*, *Thenus orientalis*, *Panulirus homarus*, and *Metapenaeus monoceros*. The two most important species, however, are *P. monodon* and *M. rosenbergii*. The Irawaddy River Delta area, comprised of swamps, mangroves, and other estuaries, offers the best freshwater, brackish water, and marine culture sites. Burma's other coastal regions (the Rhakine coast in the west and the Tenasserim coast bordering on Thailand in the east), also have substantial wild shrimp stocks. Mining and the utilization of mangroves for charcoal production, however, are destroying the postlarval shrimp estuarine habitat and polluting potential shrimp culture sites.

As with many of the other developing nations in Asia, shrimp farmers in Burma primarily use extensive methods. Yields are low (1.1 t per ha for freshwater and 0.1 t per ha for marine species), and farmers usually harvest just one crop per year.

The state-owned People's Pearl and Fishery Corporation (PPFC), Burma's sole shrimp farming and exporting organization, originally emphasized freshwater shrimp culture. Burma's first freshwater hatchery, located at Thaketa in the Rangoon District, was completed in 1986, and reportedly produced 10 million pl in 1990. A second freshwater hatchery, located at Kyauktan (Rangoon District), reportedly has the same capacity as the hatchery in Thaketa. The PPFC plans to build another freshwater hatchery, also to be located in Rangoon District.

Burmese shrimp farmers have placed more emphasis on marine species harvests during the late 1980s. Of the 4,030 t of cultured shrimp harvested by Burmese farmers in 1990, approximately 4,000 t were marine species. The recent emphasis on marine shrimp is also evident in terms of pond area. Of the total 2,920 ha under cultivation, nearly 96 percent is dedicated to marine shrimp culture. Burma currently operates one marine shrimp hatchery in the city of Sandoway, with a capacity of 10 million pl per year. The PPFC plans to increase harvests through the construction of two new marine hatcheries -- one in the Tenasserim region, and the other in Arakan State.

CHINA

China is the world's leader in cultured shrimp harvests. Chinese shrimp farmers, assisted by a long-term government program and economic reforms, massively increased harvests during the 1980s. In 1990, harvests declined from the record levels of 1988, but still exceeded 150,000 t for the fourth straight year (appendix G). China has led the world in both the harvest of cultured shrimp and the production of artificially-reared shrimp seedstock since 1986. Total area devoted to shrimp culture peaked at 164,000 ha in 1988 and declined to 145,000 ha in 1989.

China's rapid increase in cultured shrimp harvests has been based mainly on the development of hatchery and pond management technology. The country's labor resources are enormous and will be an important factor in the continued growth of the shrimp culture industry. Cultured shrimp is a valuable Chinese export commodity, with the majority of exports going to Japan and the United States.

The most important cultured species in China is *P. chinensis* (also known as *P. orientalis* or Chinese white shrimp), a species adapted to cool, northern waters. This species is cultured primarily in the Yellow Sea and East China Sea coastal regions. The Chinese success with *P. chinensis* is an anomaly as other successful shrimp culture industries use tropical species (e.g. *P. monodon*). The Chinese industry is the only major shrimp culture industry conducted in temperate latitudes. *P. chinensis* characteristically has a high-quality white flesh and grows to the large sizes preferred by most export markets. In addition to *P. chinensis*, tropical and subtropical species such as *P. japonicus*, *P. merguiensis*, *P. monodon*, and *P. pencillatus* are cultured in Southern China.

Liaoning and Shandong are the northern Chinese shrimp culture industry's key provinces, with harvests exceeding 48,000 and 43,000 t, respectively, in 1990. These provinces accounted for roughly half of China's total 1990 harvest. Other important northern provinces were Hebei (29,000 t), and Fujian (23,000 t). The northern half of Fujian Province constitutes the southern biological limit for *P. chinensis*.

China's southern shrimp culture industry has not developed to the same extent as the northern provinces. Growers in the southern half of Fujian, and all of Guangdong and Guangxi Provinces, primarily harvest *P. merguiensis*. However, *P. merguiensis* are not differentiated from *P. chinensis* in Southern China, and there is consequently much mixing of the two species when exported in block form. *P. monodon* culture is increasing in the southern provinces, particularly Guangdong and Fujian. Large areas of the southern coast seem suitable for shrimp culture. The major limiting factor appears to be seedstock availability.

Chinese growers made great progress in increasing average yields during the mid-1980s, from slightly more than 0.4 t per ha in 1982 to about 1.2 t per ha in 1987. Average yield dropped to about 0.8 t per ha in 1988, however, indicating yields may be levelling off. Average yields differ markedly between the various coastal provinces. Of the major shrimp-producing areas, Hebei Province had the highest yield in 1988, averaging 1.4 t per hectare. Liaoning and Fujian Provinces were second in average yield, reporting 0.9 t per hectare. Other provinces reported comparatively low yields, particularly southern provinces such as Guangxi and Guangdong, because of the predominance of extensive farms.

Recent reports estimate there are nearly 1000 Chinese shrimp hatcheries supplying pl from 70 percent wild and 30 percent captive females. The Chinese Government operates most hatcheries. Almost all of the hatcheries are relatively large

facilities capable of annually producing hundreds of millions of postlarvae. Hatchery production increased tremendously during the 1980s, from 337 million pl in 1980 to 74 billion pl in 1988. A few hatcheries opened during the 1980s were modeled after Thailand's so-called "backyard hatcheries." Because of a lack of knowledge concerning current hatchery techniques, backyard hatchery owners often invite experts from Chinese fisheries research institutions.

The startling growth in cultured shrimp harvests is the result of the Chinese Government's overall emphasis on aquaculture. Aquaculture is seen as the key to China's goal of raising fisheries production to 18 million t by the year 2000. Most of China's aquaculture research and promotion has been directed at expanding harvests of carp and a variety of low-value species for domestic consumption. Government planners, however, have also promoted shrimp culture to increase export earnings. Specific Government measures to support shrimp culture include:

1. Playing an active role in accelerating development of the industry in its initial stages through planning, organizing, and coordinating various aspects, including harvesting, processing, and trade.

2. Allowing foreign exchange earned from shrimp exports to be used by growers instead of turning it over to the state. In addition, shrimp products were tax exempt for the years 1979-84.

3. Allocating more than $20 million in grants and releasing a large sum of development loans at low interest rates during 1979-85.

4. Initiating a highly respected nationwide research program, with the cooperation of more than 10 institutes, universities, and farms. The research emphasizes seed production, feed and nutrition, diseases, and farm management systems. Extension work has also been strengthened to facilitate technology transfer.

There is great potential for continued shrimp culture development in China. Only about a quarter of the 8 million ha of water area available for aquaculture in China is currently under cultivation. The industry is still centered in the north, where yields are relatively low. Only limited development of southern China's significant potential has occurred. Despite the remarkable growth in China's shrimp culture industry, many problems face the country as it attempts to increase harvests. The most pressing problems include pollution, lack of basic infrastructure, unstable supplies of seedstock, and the high cost of feed.

FIJI

Fiji cultures shrimp primarily for its domestic market. The Fiji Development Bank began to experiment with the possibility of developing a shrimp culture industry in the mid-1980s. A test site for raising *Penaeid* shrimp was established in Raviravi (a recently reclaimed mangrove area) and was managed by a joint venture between the Fiji Development Bank and France Aquaculture, Ltd. The farm performed well below potential, however, and was purchased by an Australian firm in 1989. It was hoped that this takeover would lead to improved yields, but during 1990 the farm harvested only 46 percent (12 t) of the planned 25 t of *Penaeid* shrimp. The shrimp were valued at $241,000 and sold mainly to local hotels.

Fiji has one freshwater hatchery, located at the Fiji Fisheries Division Northern Research Station. The hatchery produced approximately 8,000 *Macrobrachium rosenbergii* pl in 1990, 6,000 of which were exported to Western Samoa while the remainder were used for research.

HONG KONG

Some limited extensive shrimp culture, known as the "tambak" method, is practiced in Hong Kong. This method entails the opening of pond gates at high tide to allow young shrimp and other fish to enter pens where they are kept until they reach marketable size. Most of this shrimp farming takes place on a very limited scale in the Northwestern part of the New Territories known as Mai Po. No information is available on the number of ponds currently under cultivation. *Penaeus*, *Metapenaeus*, and *Palaemon* spp. are the main species of shrimp being raised. Hong Kong has no shrimp hatcheries. Statistics are not available for cultured harvests, but the total 1990 Hong Kong shrimp catch is estimated at 11,500 tons. Hong Kong fisheries officials expect this number to decrease in 1991 to 11,000 tons. The Department of Agriculture and Fisheries successfully experimented with freshwater *Macrobrachium rosenbergii* culture in 1985, but found that culture of this species was not feasible because of the local preference for marine species.

The Hong Kong Government offers no specific assistance or fiscal incentives for shrimp culture

promotion. The Department of Agriculture and Fisheries does, however, provide technical assistance for the development of aquaculture in general. Financial assistance is also provided by the Kadoorie Agricultural Aid Loan Fund (privately funded but publicly administered) to aid in the development of the Hong Kong aquaculture industry.

INDIA

India's cultured shrimp harvests increased from an estimated 15,000 t in 1982 to about 32,000 t in 1990 (appendix H). Approximately 60,000 ha of ponds are reportedly under cultivation (out of a potential 1.4 million ha), primarily under traditional methods of rice paddy/shrimp farming employing extensive methods. Shrimp is cultured in the rice fields of Kerala, Karnataka, Maharashtra, Goa, and West Bengal -- alternating one crop of shrimp during December-January to May-June with paddy cultivation during the period of June to December. After the rice is harvested, the incoming tides trap the shrimp and other fish which are harvested at frequent intervals. No fry stocking takes place, nor are any artificial feeds used. All water management occurs through tidal exchange.

The yield using extensive methods is variable, ranging from 0.2-0.5 t per hectare. Recently adopted extensive methods in Andhra Pradesh, Orissa, Tamil Nadu, and Kerala have achieved yields of up to 2.0 t per hectare.

A great variety of shrimp abound in the offshore and inland waters of India. Nearly 52 species contribute to the fishery, and of these, about eight species of *Penaeid*, and six species of non-*Penaeid* are of considerable significance. Within the shrimp culture industry, however, *P. monodon* and *P. indicus* (Indian white shrimp) are the two most important species. Recent reports indicate that approximately 70 percent (22,400 t) of the 1990 cultured shrimp harvest was *P. monodon*, while 20 percent (6,400 t) was *P. indicus*, with the remaining 10 percent consisting of species such as *Metapenaeus dobsoni* and *Parapenaeus stylifera* (brown shrimp).

The Government of India has realized that there is vast potential for earning foreign exchange through cultured shrimp exports. Consequently, a national policy has been formulated to promote the shrimp culture industry and ensure that India retains its status as one of the leading world shrimp producers. Under the 8th five-year plan (1991-1995), the Marine Products Export Development Authority (MPEDA) will continue technical and financial assistance programs begun under the 7th five-year plan. Shrimp farmers will receive up to $2,900 for developing areas of 10 ha or more.

Recognizing that the regular supply of quality pl is essential for the industry, the MPEDA will also continue its small-scale shrimp hatcheries program. Farmers may receive subsidies of up to 50 percent on the capital cost of equipment for establishing small-scale hatcheries. Supplementary feeding, considered essential to increasing harvests, will also be promoted through a 25 percent feed subsidy to small farms (2 ha or less) and a 50 percent feed subsidy to larger farms.

Technical assistance for shrimp culture projects will also continue under the 8th five-year economic plan. Field offices established for shrimp farming promotion in Cochin, Karwar, Barasat, Bhubanesware, Vijayawada, Tnajavur, Valsad, and Alibag will help farmers select sites, prepare project reports for arranging credit, construct farms, prepare ponds, secure pl, select stock, and manage ponds. The MPEDA will also organize short-term training programs, farmers meetings, and workshops. The Government of India hopes that an additional 5,000 ha (3,000 ha extensive and 2,000 ha semi-intensive) will be brought under cultivation by 1995.

Indian shrimp culture still depends largely on wild seed stock collected from estuaries, but hatchery-produced seed stock are now available from 12 hatcheries. The MPEDA has constructed hatcheries in Andhra Pradesh and Orissa in collaboration with respective state governments. The Andra Pradesh hatchery, located near Visakhapatnam on the east coast, has technical collaboration with Aquatic Farms Ltd. of Hawaii. The Orissa Shrimp Seed Production, Supply, and Research Center (OSPARC) operates a hatchery in conjunction with France Aquaculture Company which produces 40 million pl per year.

In addition, there are private hatcheries located in Tuticorin, Madras, and Karnataka, and state Government hatcheries in Kerala, Madras, and Maharashtra. Small quantities of shrimp seed are supplied to farmers by the experimental hatcheries of the Central Institute of Brackish Water Aquaculture, the Gujarat Fisheries Aquatic Science Research Institute, and the MPEDA hatchery in Cochin.

The Danish Aid Agency (DANIDA) has reportedly agreed to finance a fresh-water prawn

hatchery that will benefit 50,000 farmers in West Bengal. Promoted jointly by the MPEDA and West Bengal Government, the hatchery will have an annual production capacity of 40 million postlarvae.

New shrimp farming projects include a proposal by the Indian Tobacco Company (ITC) (in technical collaboration with Allied Seafoods of Singapore) to establish two 300 ha *P. monodon* and *P. indicus* farms in Visakhapatnam and Tuticorin. This project is expected to start by the end of 1992. ITC also plans to establish shrimp processing plants in Visakhapatnam, Calcutta, and several other locations.

The Tata Oil Mills Company, Tata Iron and Steel Company, and Otto India Ltd. (in technical collaboration with Victory Farms of Tamil Nadu and Allied Seafoods of Singapore), plan to establish a 600 ha shrimp farm in Orissa. The Orissa State Government will have a 49 percent equity share in the project named Chilka Aquatic Farms Ltd. **Note**: An earlier company, Tata Aquatic Farms, in collaboration with Aquatic Farms Ltd. of Hawaii went bankrupt.

High-quality shrimp feed is not yet commercially available in India. Some private companies have produced sample feeds which are being tested in the field. Since shrimp farmers are unhappy with the quality of feed available in India, the Indian Government allows the import of feed at a concessional duty rate. Shrimp exporters receive total exemptions from feed import duties.

A shrimp feed plant located in West Bengal, said to be the first of its kind in India, is expected to begin production in 1992. The plant was established in technical collaboration with the Dievet Company of France and will have an annual capacity of 60,000 tons. The plant will use agricultural and marine waste for raw materials. The feed will be sold for approximately 75 cents per kilogram.

INDONESIA

Indonesia's cultured shrimp harvest in 1990 was an estimated 120,000 t, making Indonesia the world's second largest harvester of cultured shrimp behind China (appendix I). The 1990 harvest reflects substantial new domestic and foreign investment in Indonesian shrimp farms.

Indonesia has approximately 130 large-scale hatcheries, each of which produces an annual average of 50 million postlarvae. A small-scale hatchery industry has recently emerged in response to excess demand for pl, however, and this trend will likely continue. The major species cultured are *P. monodon*, *P. merguiensis*, and *P. indicus*. There are currently 300,000 ha of pond area under cultivation out of an estimated 3 million ha of land suitable for shrimp culture. Government officials estimate that approximately 190,000 ha are under extensive culture, 90,000 ha under semi-intensive culture, and the remaining 20,000 ha under intensive culture.

Brackish water aquaculture has a centuries-long tradition in Indonesia. It developed from a mangrove swamp fishery using traps constructed as simple tidal ponds. The majority of the tidal culture ponds (or "tambaks" - see Hong Kong) are located along the northern coast of Java, southern Sulawesi, and the province of Aceh in Sumatra. Traditional methods of milkfish and shrimp culture are still in use by a majority of Indonesian pond managers. Ponds are stocked with fish and shrimp swept into them with the incoming tide and then caught by straining the pond water as the tide ebbs. There is little control over water depths and salinity levels and no additional stocking or feeding is done. Ponds are typically harvested twice a year. Annual yields are low, ranging from 0.3-0.4 t per hectare. Shrimp is usually only a small portion of the total harvest.

A ban on shrimp trawling along the coast of Java and an increase in the world demand for shrimp induced tambak operators to concentrate on harvests of shrimp rather than milkfish in the early 1980s. Pond managers also began to adopt semi-intensive culture practices, including improved control of salinity and water depths, and increased stocking and feeding.

Additional changes in the industry have centered around commercial development of intensive-culture tambaks, using predominantly Taiwanese technology. There has been considerable improvement in pond construction methods, with tambaks being constructed specifically for the harvest of *P. monodon*. Pumps and paddle wheels are being used to facilitate water exchange and improve pond aeration. Pond managers have also increased stocking rates and are using formulated feeds. The new intensive ponds can yield 4-7 t per ha per crop, with some managers reporting two or more harvests per year.

Shrimp culture has attracted the interest of a wide range of Indonesian businessmen. Most of the new intensive and semi-intensive ponds constructed during

1988-90 have been financed by corporate investment rather than by the tambak owners. According to Indonesia's Capital Investment Coordinating Board (BKPM), domestic investment in the fisheries sector quadrupled between 1985 and 1988. Foreign investment in the fishing industry has increased at an even more rapid pace: from $12 million in 1987 to approximately $170 million in 1988, a fourteen-fold increase.

Joint ventures are the most common form of foreign investment in the Indonesian shrimp culture industry. Japan, as the largest consumer of Indonesian shrimp, is involved in the most joint venture operations, but a number of Indonesian shrimp farmers and processors have expressed a desire to exchange their dependence on the volatile Japanese market for more stable U.S. trade.

The Indonesian Government has promoted the domestic shrimp culture industry since the 1970s when the Fisheries Department constructed four freshwater *Macrobrachium* hatcheries. More recently, in its efforts to boost non-oil exports, the Government has promoted shrimp culture as a leading foreign exchange earner and employer. The Government provides investment incentives and credits, working capital, export credit, and technical expertise.

Indonesia is also the recipient of a considerable amount of technical and financial assistance from international development aid organizations. The two leading donors are the Asian Development Bank (ADB) and the United Nations Development Program (UNDP). The ADB is currently involved in a $22.4 million project that will take place during 1990-95. The project will provide credit to companies and selected land owners to help construct ponds and shrimp hatcheries. About 1,300 families are expected to benefit from the project, with each family earning about $5,000 per year. The UNDP has recently completed a five-year program which financed the construction of 3 regional shrimp culture development centers and provided training and technical assistance in the construction of several hatcheries.

The Indonesian Government has limited commercial farmers to 30 ha of company-owned ponds to protect small-scale traditional farmers. This limit can be extended under a "nucleus estate system." Many companies in the industry are becoming increasingly vertically integrated, operating their own hatcheries, ponds, processing plants, and cold storage facilities. Processing companies are also offering extension services to the pond owners.

JAPAN

Japan was a pioneer in shrimp culture technology, but harvests have stagnated during the late 1980s at the 3,000 t level (appendix J). The two main reasons for this are: 1. a shortage of coastal areas with a warm climate conducive to aquaculture, and 2. high labor costs. Shrimp culture accounted for only 7 percent of Japan's 1990 shrimp production.

Penaeus japonicus, the kuruma prawn, is the most important farmed species in Japan. It is generally marketed live and sold to luxury restaurants and department stores which sell them in expensive gift packages. *Odori* (dancing shrimp), the ultimate shrimp dish in Japan, consists of *P. japonicus* that "dance" on the counter while they are peeled live. Japanese diners often pay as much as $10 per shrimp for this delicacy.

P. japonicus are expensive because they cost a great deal to culture. Compared to other major commercial species, *P. japonicus* culture is extremely labor-intensive. Production costs average about $7 per kg (including feed costs of about $3 per kg).

The high cost of intensive farming is leading some farmers to adopt a lower-tech, lower-cost approach, especially in view of increasing *P. japonicus* harvests from low-cost harvesters like Taiwan. Freshwater prawn culture (primarily *Macrobrachium rosenbergii*) is relatively new in Japan, and harvests are negligible compared to marine shrimp culture.

Roughly 165 farms covering 500 ha, evenly split between semi-intensive and intensive methods, were under cultivation in 1990. These farms were supplied by approximately 40 hatcheries. Because it is difficult to obtain suitable land and/or water rights for shrimp culture in Japan and because of the country's poor shrimp growing climate, the area under cultivation will probably not change much in the future.

Four types of enclosures are used to cultivate shrimp in Japan. They are: 1. unused salt fields, 2. concrete or stone dikes, 3. sea pens or cages, and 4. small circular concrete tanks. Unused salt fields are the most prevalent type of enclosure. Japan's strict coastal resource management laws have restricted farms both in size (to prevent conflicts with existing fishermen) and number (to maintain price stability).

To enhance wild shrimp catch, the Japanese practice shrimp "ranching" (i.e. releasing pl into the sea to increase coastal stocks available to commercial fishermen, primarily the inshore gillnet fleet). Nearly every prefecture in Japan has its own shrimp ranching hatchery. The prefectures surrounding the Seto Inland Sea and those in central and southwest Japan produce the largest quantities of juvenile shrimp. The effectiveness of ranching, however, has yet to be determined.

The Fisheries Agency of Japan (FAJ) provides fiscal incentives to fishery cooperatives engaged in shrimp culture. The FAJ, along with the Finance Corporation of the Ministry of Agriculture, Forestry and Fisheries, also offers low interest loans to promote shrimp culture.

REPUBLIC OF KOREA (ROK)

The 1990 ROK cultured shrimp harvest was approximately 300 t, less than one percent of the total shrimp catch of 58,000 tons (appendix K). Cultured shrimp harvests have averaged about 150 t per year since 1983. The ROK currently has 1,020 ha of shrimp ponds under cultivation, supplied by 29 hatcheries with an aggregate annual capacity estimated at 150 million postlarvae. The main species presently under cultivation is *Penaeus orientalis* (Chinese white).

All ROK cultured shrimp harvests take place in brackishwater ponds using semi-extensive methods. The recent increases in harvests can largely be attributed to the increased use of formulated feeds. The two major private actors in Korea's shrimp culture industry are Doosan Industrial Company and Jinro Food Company, which respectively operate 80 and 15 percent of existing farms.

As in Japan, the relatively low level of growth in the Korean shrimp culture industry may be attributed to two major factors:

1. Climate: The ROK does not have a climate conducive to shrimp culture. Farmers have had problems maintaining the correct salinity levels in their ponds due to frequent typhoon activity along the country's coasts. In addition, temperatures are too cool for optimum shrimp growth.

2. Availability of pond sites: There is a scarcity of suitable pond sites for shrimp culture. The number of shrimp ponds is dependent on coastal reclamation projects, but the high investment cost of these projects has restrained shrimp culture development.

The ROK has no current plans for expansion of its shrimp culture industry because of the capital-intensive nature of shrimp farming. In addition, the ROK's supply needs are met by increased shrimp imports (shrimp imports have recently been liberalized). The ROK government has established no separate policy, nor provided any fiscal incentives, that might serve to encourage increased shrimp culture harvests.

The private sector plays an important role in the promotion of ROK shrimp culture. The Doosan Industrial Company, for example, regularly trains its shrimp farmers in improved culture methods. Doosan also actively works with local fishermen by providing equipment and technical assistance for use of abandoned salt ponds in shrimp farming.

MALAYSIA

Malaysian shrimp culture has begun to succeed commercially after years of financial losses. Improved methods and the commitment of a few large companies are largely responsible for the turnaround. The 1990 Malaysian harvest was estimated at 2,500 t, an increase of 14 percent over 1989 (appendix L). *P. monodon* constitute nearly 90 percent of the Malaysian harvest, with the remaining 10 percent being *P. merguiensis* and the freshwater prawn, *Macrobrachium rosenbergii*.

Malaysia has considerable potential for shrimp culture development. It possesses an estimated 110,000 ha of coastal areas which are suitable for shrimp culture. The Malaysian Government plans to develop 24,000 ha of shrimp ponds and harvest 48,000 t of shrimp by the year 2000. The Government approved numerous shrimp culture projects during the late 1980s. Many of the projects are joint ventures with Taiwanese partners. Some of the larger projects have their own hatcheries, and some are integrated with processing plants. At present, 26 hatcheries are registered with the Malaysian Fisheries Department. Pl production in 1990 was approximately 600 million.

Three major corporations have played a leading role in the development of Malaysian shrimp culture. They are: The Johor State Economic Development Corporation, which operates East Asia Marine Farms (EAMF); the Anglo-Dutch Unilever Corporation; and

the Lion Corporation. These firms conduct semi-intensive operations with yields averaging 1-2 t per hectare.

Malaysia has received considerable Japanese aid to promote shrimp culture. The Malaysian National Prawn Research Center was completed in 1987 with a $8.4 million grant from the Japanese Government. It also received assistance from two Japanese aquaculture experts supplied by the Japanese International Cooperation Agency. The Center has cut Malaysian pl production costs by 50 percent over the past five years. A new technique for mass pl production through induced spawning was developed at the Center and is being applied at most of Malaysia's hatcheries.

The Malaysian Government assists the shrimp culture industry through the Department of Fisheries, which provides advice and technical assistance. Shrimp culture firms are eligible to receive tax rebates and tax relief, which the Government provides to most developing industries. A 5 percent investment tax credit is extended to all shrimp culture investors. Investors may also borrow from the Government's low-cost investment fund at reduced rates or benefit from a reduced interest rate export credit financing scheme.

NEW CALEDONIA

Researchers on New Caledonia (a French territory located in the South Pacific) work with a wide range of species, but concentrate on cultivating a Mexican strain of *P. stylirostris* in semi-intensive farms. New Caledonia has one shrimp feed mill and four private farms. The largest farm, SODACAL, has 220 ha of ponds (with plans to expand to 1000 ha by 1997) and expects to harvest about 200 t in 1992 at a cost of $8.70 per kilogram. SODACAL also has a hatchery and a processing plant. The second-largest farm, AQUAMON, has 25 ha of ponds. New Caledonia harvested 350 t of shrimp in 1989, and the 1990 harvest is estimated at 500 tons. Most of the shrimp is exported for a price of approximately $9 per kilogram.

NEW ZEALAND

There is currently only one small, privately-owned shrimp farm in New Zealand which began production in 1990. Aquatech Farms Ltd. operates a 1 ha freshwater shrimp pond that produces about 9 t per year. The only cultured species in New Zealand is *Macrobrachium rosenbergii*. The cultured shrimp is sold exclusively on the domestic market to hotels and restaurants. Aquatech is reportedly considering an expansion of its New Zealand operations, however, and is investigating export markets.

Aquatech also operates the only freshwater shrimp hatchery in New Zealand, Wairake Shrimp Farms. The hatchery's annual capacity is 12 million postlarvae, but current annual production is only 1-2 million post-larvae. Aquatech also owns one marine shrimp hatchery, but it has not been used since 1989 because of financial difficulties and a lack of broodstock.

PAKISTAN

Shrimp culture operations in Pakistan have essentially ceased, and no significant shrimp harvest is expected in the near future (appendix M). Pakistani fishery experts believe that the Indus Delta region along the southeast coast has the greatest potential for future shrimp culture development. Despite the vast tracts of brackish water area available, however, only four experimental farms have been established to investigate the Delta's shrimp culture potential.

One of these projects, an experimental *P. monodon* shrimp farm financed by the Asian Development Bank (ADB) was established at Gharo. Using pl trapped from local streams, the rearing process was supervised by U.S. consultants. The experiments were unsuccessful, however, because the indigenous species did not grow large enough and had a high mortality rate. The Government of Pakistan also gave permission for the establishment of two other farms -- Aquaworld and Balochistan Sea Farm-- but neither have shown positive results.

The only successful example of shrimp farming in Pakistan was that of Lever Brothers (originally Lipton Ltd.) which cultured shrimp experimentally in the Thatta District of Sindh Province. The Lever Brothers farm harvested 20 t of *P. monodon* in 1989 - 90 percent of Pakistan's total farmed shrimp harvest that year. The Lever Brothers farm discontinued operations in 1990 because it lacked hatchery facilities and relied on imported post larvae. Political instability in Sindh Province also contributed to the shutdown.

PHILIPPINES

Philippine farmers harvested 54,000 t of shrimp in 1990 (appendix N), accounting for 79 percent of total Philippine shrimp catch. The Philippine shrimp culture industry has expanded each year since the early 1980s, but not as explosively as Thailand and Indonesia. Some multinational companies have established high-yield intensive shrimp farms in the Philippines, but many Filipinos are farming shrimp using traditional extensive methods. The most important species is *P. monodon*, which constituted approximately 90 percent of the total harvest and over 60 percent of total shrimp catch in 1990.

Extensive shrimp culture in the Philippines uses natural pond growth (algae) as food, with little or no supplemental feeding. Stocking densities are low (5,000-30,000 pl per ha), and average yield is less than 0.5 t per hectare. The long growout period usually means that only one crop is harvested per year. Extensive farms are located throughout the Philippine Archipelago, but are concentrated on the Island of Panay in the central Philippines. Many rice and sugar farms on the Island of Panay have been converted to shrimp farms.

Philippine shrimp farmers using **semi-intensive** methods depend on supplemental feeding in addition to pond algae. Stocking densities range from 30,000-200,000 pl per ha, and average yield varies from 0.5 t to 3.0 t per hectare. Two crops can usually be produced annually. Lower stocking densities (usually in the range of 50,000 pl per ha) are preferred in the Philippines because farmers using higher densities have encountered disease problems.

Intensive shrimp culture farmers use only pelletized feeds. Stocking densities range from 200,000-500,000 pl per ha, and average yield varies from 3-10 t per hectare. Intensive farms exist on many islands of the Philippine Archipelago, but are concentrated on the southern islands of Negros and Mindanao.

All but the most extensive shrimp farms in the Philippines depend on artificial feed to promote rapid shrimp growth. There are presently about 21 shrimp feed plants operating in the Philippines, annually producing 100,000 t of feed and supplying 85 percent of shrimp farmers' needs. The San Miguel Company, which is active in all phases of the shrimp farming industry, is the largest feed producer in the Philippines.

Shortages of pl have been a significant factor limiting Philippine harvests. For many years, Philippine shrimp farmers relied exclusively on pl caught at sea or collected in estuaries (many extensive farmers still do). As intensive and semi-intensive methods came into use, however, hatcheries were established to meet the growing demand for post larvae. There were approximately 300 shrimp hatcheries in the Philippines in 1990 (more than double the 1986 number), with a combined monthly production capacity of over 500 million post larvae. These hatcheries reportedly supplied 75 percent of the country's pl requirements.

Hatcheries in the Philippines range in size from backyard operations (producing less than 1 million pl per month) to large-scale commercial enterprises (producing 5-10 million pl per month). Many of the larger intensive shrimp farms, which depend on high pl stocking densities to maximize output and profits, have built their own hatcheries.

Although the increased number of hatcheries has partially alleviated one problem for Philippine shrimp farmers, most hatcheries still depend on the irregular supply of wild-caught gravid shrimp. Such spawners have become valuable commodities (a single gravid female cost over $50 in 1988), and it is illegal to export them from the Philippines. Some modern hatcheries, such as the one operated by the Purefoods Company on Luzon Island have overcome this obstacle to pl production by breeding spawners.

The overall area devoted to shrimp culture has not expanded significantly during the last five years. Roughly 22 percent (48,400 ha) of the 220,000 ha of Philippine brackish water ponds is utilized for shrimp culture. There have, however, been changes in the use of existing hectarage. The Philippines Bureau of Fisheries and Aquatic Resources (BFAR) claims that many milkfish/shrimp polyculture ponds have been converted to shrimp monoculture ponds.

The Philippine Board of Investments has extended incentives to shrimp producers, feed manufacturers, and those offering refrigeration/ storage services for shrimp products. These incentives are mostly in the form of tax and duty-free import privileges for equipment. In the field of research and development, the BFAR has regional research centers which provide technical assistance to hatchery owners and shrimp growers. Recently, BFAR opened a research center in Manila which provides free tests designed to detect shrimp disease. This service has been very helpful in detecting

monodon baculovirus, a disease which nearly wiped out *P. monodon* intensive culture in Taiwan.

The ash fall and mudflows caused by the 1991 eruption of Mt. Pinatubo damaged some growout ponds in the provinces of Bataan and Zambales in the northern Philippines. Some hatcheries have also closed, causing domestic pl prices to triple. The loss in harvests from these areas, however, is not expected to affect the industry significantly in the long-term.

Shrimp culture will probably continue to expand in the Philippines. The country has nearly ideal conditions--climate, water quality, soil characteristics--for shrimp culture. The Philippines already has the infrastructure to support a larger shrimp culture industry and is located close to Japan, a major shrimp market.

There is growing concern in the Philippines, however, about the harmful effects of shrimp farming on the environment. One problem is the destruction of coastal mangrove forests to create growout ponds. These forests are important breeding grounds for many species of fish and shellfish. A potentially more serious problem is the effect of semi-intensive and intensive shrimp farming on the freshwater supply in the Philippines. Semi-intensive and intensive farms require a steady supply of fresh water to prevent contaminants from accumulating in the densely stocked shrimp ponds. Many intensive farmers rely on wells to provide fresh water, and their growing use is placing heavy demands on underground springs.

SINGAPORE

Singapore's cultured shrimp harvest was estimated at 50 t in 1990 (appendix O) -- far short of the 300 t projected for 1990 by Singapore fishery officials in 1987. Shrimp farming in Singapore was traditionally conducted in earthen ponds with low annual yields -- ranging from 0.3 t per ha in extensive culture to 2-5 t per ha in semi-intensive culture. In the mid-1980s, the Singapore Primary Production Department (PPD) carried out studies on the farming of *Penaeus merguiensis* in floating netcages. Although the results of the study were favorable, shrimp culture has failed to develop into a significant industry. The Government of Singapore provides no fiscal incentives for the development of shrimp aquaculture, but the PPD continues to provide technical assistance to the island's small community of shrimp farmers.

While Singapore is only a minor shrimp harvester, recent reports indicate that it is making efforts to take part in the Asian "shrimp boom" as a processor of raw material and supplier of shrimp feed. Tenneco Ltd., and Sigma Food Products Ltd., are both building state of the art shrimp processing plants in Singapore. The plants will include facilities for peeling, cleaning, freezing, glazing, and retail packing.

The Gold Coin Company recently announced plans to construct a sophisticated shrimp feed plant in Singapore. Gold Coin reportedly intends to take advantage of Singapore's strategic location to become an important supplier of high-quality feed to shrimp farmers in Malaysia, Indonesia, Thailand, Sri Lanka, India, and the Philippines.

SOLOMON ISLANDS

There is negligible commercial shrimp culture in the Solomon Islands. One company, South Pacific Aquaculture Ltd., is culturing the freshwater prawn, *Macrobrachium rosenbergii*, at Aruligo, West Guadalcanal. The company is also exploring the possibility of culturing marine penaeid shrimp.

SRI LANKA

Sri Lanka first harvest of cultured shrimp was 89 t in 1985. Since that time, cultured shrimp harvests have increased considerably. Sri Lanka's 1990 harvest of farmed shrimp was estimated at 800 t (appendix P) -- nearly nine times the initial 1985 harvest. There are currently 400 ha under cultivation, with an estimated 300 ha of unused capacity. *P. monodon* is the dominant cultured species.

Most Sri Lankan shrimp farmers employ semi-intensive methods with stocking densities ranging from 30,000-60,000 pl per hectare. The average annual yield is 2-5 t per hectare. There are currently 5 operational marine shrimp hatcheries in Sri Lanka, with an annual capacity of 110 million post-larvae. Present hatchery production is approximately 60 million pl per year.

There are approximately 15 companies currently involved in Sri Lankan shrimp farming. The largest, Lever Aquaproducts Ltd., is a fully integrated company whose operations include a hatchery and feed plant. Lever Aquaproducts also runs the most intensive shrimp culture operation in Sri Lanka, with stocking densities in excess of 60,000 pl per hectare. Many of the smaller, semi-intensive farms in Sri

Lanka point to Lever Aquaproduct's use of intensive culture systems as the cause behind an outbreak of *monodon baculovirus* which reduced that company's harvest by nearly 50 percent in 1988. Hatchery operators have reportedly introduced new methods to identify and select disease-free post larvae, and most intensive farms have switched to semi-intensive culture.

The Government of Sri Lanka withdrew Government support for aquaculture on Buddhist religious grounds (animals should not be killed) on July 24, 1990. This decision has serious implications for the shrimp culture industry as the Government earlier had plans to develop small-scale freshwater shrimp farming. The Export Development Board (EDB), a semi-governmental organization, formerly assisted shrimp culture projects. Consequent to the withdrawal of government aid, however, the EDB no longer participates in financing new shrimp culture projects but continues to assist in market development and promotion efforts. A 5-year tax holiday is also still available for shrimp farmers.

TAIWAN

Taiwan's shrimp culture industry experienced a period of meteoric growth between 1981 and 1987, with harvests growing by over 1,200 percent (appendix Q). Key to this growth was the development of *P. monodon* into a profitable species for intensive Taiwanese shrimp culture. Acceptance of the *P. monodon* in the Japanese and U.S. markets opened the world's most important shrimp markets to Taiwan's shrimp farmers, and Taiwan became Asia's leading cultured shrimp harvester in 1986.

A second development instrumental to the 1980s shrimp culture boom was the introduction of balanced feeds specifically designed for *P. monodon*. The low average cost of domestically-produced pellet feeds (about $1 per kilogram) aided the profitability of *P. monodon* culture and contributed to the sudden rise in harvests. After the introduction of balanced feeds in the mid-1970s, Taiwan's shrimp harvests soared from less than 100 t in 1975 to a peak of 114,500 t in 1987. Domestic production of feeds mirrored this rise, climbing from 110 t in 1977 to over 100,000 t by 1986. The pond area devoted to shrimp culture also showed dramatic change, rising from 3,500 ha in 1981, to 17,500 ha in 1988.

A third factor that paved the way for large-scale *P. monodon* culture in Taiwan was the construction of private hatcheries. Taiwan's farmers developed the largest shrimp hatchery industry in the world. Approximately 2,000 shrimp hatcheries and nurseries produced more than 4 billion *P. monodon* pl in 1988. There is no longer a wild shrimp seed collecting industry on Taiwan. Competition from so many hatcheries working at maximum capacity has kept the price of shrimp seed relatively low.

The Taiwan shrimp culture industry collapsed in 1988. Much of Taiwan's *P. monodon* industry was wiped out by a combination of poor culture practices, polluted water, and the spread of *monodon baculovirus* (MBV), a disease which decimated entire crops of *P. monodon* in the larval and juvenile stages of growth. Harvests decreased by 1990 to a total of only 30,000 tons.

The shrimp culture industry showed its first signs of recovery in 1990. Farmers have lowered *P. monodon* stocking densities since 1988 and switched to other disease-resistant species. The most important new species are *P. pencillatus*, *P. chinensis*, and *P. japonicus*. *P. japonicus* constituted nearly 25 percent of the 1990 harvest and has great potential as an export to Japan.

The Government of Taiwan no longer encourages shrimp culture. No fiscal incentives are provided because the rapid expansion of shrimp culture during the 1980s led to the depletion of Taiwan's ground-water level. This in turn caused coastal lands to sink in many areas. Government authorities are presently trying to eliminate illegal shrimp ponds and restrict the number of licensed ponds to a maximum of 1,000.

THAILAND

Thailand's shrimp culture industry is one of the fastest growing in Southeast Asia. In only 5 years, Thailand has surpassed its competitors to become the region's number three harvester. Thai shrimp harvests in 1988 reached 56,000 t, a 320 percent increase over the 13,000 t harvested in 1984. Indonesian and Philippine harvests rose by only 62 and 51 percent, respectively, over the same time period. Thailand's 1989 harvest nearly doubled the 1988 level, surpassing 93,000 tons. As happened in Taiwan during 1987, however, disease in Thailand's central provinces limited total harvests for 1990 to an estimated 100,000 tons (appendix R). From 1985-90, the area under cultivation doubled from 41,000 ha to 85,000 hectares. The three principal species under cultivation are *P. monodon, P. merguiensis, and P.*

indicus, constituting 85 percent, 10 percent, and 5 percent, respectively, of the 1990 farmed shrimp harvest.

Thailand's rapid development of a commercial shrimp culture industry is remarkable given its late start. Thai farmers have long been adept at using traditional extensive shrimp farming methods. In the past ten years, however, the industry has been dramatically transformed by the introduction of intensive and semi-intensive methods. Of Thailand's approximately 3,000 operational shrimp farms, 60 percent use intensive methods, 10 percent use semi-intensive methods, and 30 percent use traditional extensive methods.

Thailand has approximately 1,500 hatcheries. Forty percent are small-scale hatcheries, 40 percent are medium-scale, and the remaining 20 percent are large-scale. Small-scale backyard hatcheries have been very successful in Thailand and contributed greatly to the rapid growth of the shrimp culture industry. Medium and large-scale hatcheries have gained in popularity recently, however, as farmers shift to more intensive methods which require more postlarvae.

Another significant trend is contract farming. Large corporations train pond owners, sell them seedstock and feed, and then purchase the shrimp when they reach a marketable size. Owners retain title to their ponds and personally manage them. Some large feed companies have backed similar contract farming operations.

Thailand's *P. monodon* industry changed dramatically during 1990 as prices doubled to nearly $8 per kilogram. A major factor in this change was the sudden collapse of shrimp culture in Samut Sakhon and other central coastal provinces. Overstocking and poor drainage spread the *monodon baculovirus* disease which devastated the 1990 crop. The central provinces which formerly harvested about 70 percent of total Thai cultured shrimp, now account for no more than 10 percent. Eastern provinces, such as Chantaburi, have also been adversely affected and, as a result, the south's share of shrimp harvests skyrocketed in 1990 from 10 to 50-60 percent. Processing plants in the central region, suddenly bereft of supply and faced with fixed operating costs and overseas contracts, are offering premium prices for southern shrimp.

Aquastar and Charoen Pokphand (CP) are the two largest firms in the Thai shrimp culture industry. Both are vertically integrated enterprises which cultivate shrimp from eggs through nursery larvae to adult shrimp in growout ponds. Vertical integration keeps operating costs significantly lower for these two firms and allows them to dominate the Thai shrimp industry. A brief summary of each company's activities follows:

Aquastar: Aquastar, a Thai company with American shareholders, first entered the shrimp culture industry when it bought 38 ha of coastal rice paddy in southern Thailand's Kanod District in 1985. After successful harvests from demonstration ponds, Aquastar negotiated with 293 landowners in seven locations to convert their paddy fields into 310 semi-intensive shrimp ponds (1 ha each), with financing from the Bank of Thailand. Aquastar provided training and follow-up extension services. Aquastar expanded its operations to 41 new ponds covering 40 ha during 1990. The Bechtel Corporation of the United States supervised the construction of these ponds, which comprise part of Aquastar's ambitious expansion plan for 500-600 ponds in 50-pond clusters. Yields in Aquastar's growout ponds have averaged 5-6 t per ha, with some ponds producing as much as 7-9 t per hectare.

Charoen Pokphand: The Charoen Pokphand group (CP) initiated shrimp culture operations in 1988, purchasing large tracts of paddy land in the Hua Sai area of southern Thailand (Nakhon Si Thammarat Province) and converting it into ponds. CP, a Bangkok agro-industrial conglomerate, is the world's fifth largest producer of animal feed and has a wide range of interests in Asia and the United States. CP began the construction of two farms in Hua Sai in January 1989: one totally CP-owned (Nakorn Farms), and one a joint venture with Mitsubishi Corporation of Japan (Thai Prawn Cultivation Center, TPCC). Both operations include a hatchery, nursery, and feed mill. Nakorn Farms' growout ponds total 96 ha, TPCC's 80 hectares. TPCC and Nakorn Farms have prospered with a stocking density of 30 pl per square meter, and yields have averaged 6 t per hectare. The company plans to continue its 30 pl stocking rate for the next 10 years, but technicians have expressed concern about future pollution from neighboring small-scale ponds owned by local farmers, which have proliferated at an alarming rate.

The pattern of rapid over-development and ecological disaster, as happened in Taiwan and the central provinces of Thailand, appears to be repeating

itself in southern Thailand. In general, ponds have been dug randomly along the coast. Lack of adequate financing and ignorance of proper construction methods has resulted in leaking dikes, poor water quality, and reckless discharge of effluents into canals or the ocean. Small farmers have over-stocked their ponds to as high a density as 50-60 pl per square meter in a rush for quick profits. In response to the resultant stress and viral disease, these farmers have dumped antibiotics into ponds, producing resistant strains of virus. Disease has already caused serious losses in the Amphoe Muang and Pakpanang districts of Nakhon Si Thammarat, where the same canals are used for both intake and drainage. Even some of Aquastar's ponds in Hua Sai have reported unexpectedly poor harvests.

Aware of the environmental threat posed by unchecked development, Songkhla Governor Niphon Bunyaratano convened a series of three meetings in 1991 with fisheries and research officials and representatives of the shrimp culture industry, including Aquastar and CP. As a result of this meeting, Governor Bunyaratano drafted provincial policy guidelines for shrimp culture. The governor of Nakhon Si Thammarat is expected to promulgate a similar policy for his province in the future.

VIETNAM

Vietnam's 1990 cultured shrimp harvest is estimated at 30,000 tons (appendix S). Virtually all of Vietnam's shrimp culture operations are situated in the southern half of the country, and extensive methods are dominant (roughly 90 percent of all farms). Approximately 170,000 ha of pond area are under cultivation, and the three principal species farmed are *P. monodon, P. merguiensis,* and *P. indicus*. These three species accounted for 70 percent, 20 percent, and 10 percent, respectively, of Vietnam's 1990 harvest. There are an estimated 150 hatcheries in Vietnam, but the majority are small-scale operations (1-5 million pl per year). These hatcheries supply only a small percentage of Vietnam's pl needs, however, so most shrimp farmers still rely on wild-caught postlarvae.

Family-run farms are typically 1-3 ha, while large cooperatives' and state-run farms range from 100-300 hectares. Some large farms utilize several thousand ha of tidal areas. Yields are low by international standards, averaging about 0.2 t per ha for each harvest. Increased stocking densities, pest eradication, and increased attention to water quality helped to boost yields in 1990. Recent changes in national economic policy have also provided more incentives for free enterprise. As a result, a number of new hatcheries have been constructed by the private sector. Total pl production is increasing rapidly, from an estimated 200 million in 1988 to about 500 million in 1991. The new private sector hatcheries are concentrated in Phu Kanh Province where the main research institutions are based (technical assistance is often hired from governmental institutions).

The Government of Vietnam and the Lobana Aquatic Products Corporation of Australia established Va-Tech, (Vietnam-Australia Technology Corporation), a shrimp culture joint-venture in 1988. Va-Tech provides technical guidance to local shrimp farmers, and also supplies pl, hatchery technology, feed, and packaging materials. The Thai agro-industrial company Charoen Pokphand plans to make massive investments in shrimp farms in Vietnam. Charoen Pokphand has expressed interest in Vietnam's potential as a harvester of *P. monodon*.

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APPENDICES

Appendix A.--**Asia.** Shrimp harvests, by country and fishery, with cultured shrimp as a percentage of total shrimp catch, 1989.

Country	Fishery		Total	Percent Cultured
	Wild Catch	Cultured		
	--Metric tons--			
China	327,100	175,000	502,100	35
Indonesia	152,000	97,000	249,000	39
Thailand	85,200	93,500	178,700	52
Philippines	17,600	47,900	65,500	73
Taiwan	68,400	32,300	100,700	32
India	228,000	25,000	253,000	10
Vietnam	33,000	22,000	55,000	40
Bangladesh	35	18,200	18,200	Negl.
Burma	3,000	4,000	7,000	57
Malaysia	106,800	2,200	109,000	2
Japan	42,200	2,800	45,000	7
Sri Lanka	3,100	700	3,800	19
Australia	18,900	500	19,400	2
New Caledonia	N/A	302	N/A	N/A
ROK	51,100	300	51,400	Negl.
Singapore	N/A	59	N/A	N/A
Pakistan	23,500	22	23,500	Negl.
New Zealand	Negl.	9	9	100
Fiji	N/A	7	N/A	N/A
Total	1,159,900	521,800	1,681,700	31

Negl. - Negligible.
N/A - No data available.
Sources: U.S. Embassies in listed countries, FAO Yearbook of Fishery Statistics, and other country sources.

Appendix B.--**Asia.** Cultured shrimp harvests, by country and quantity, 1983-91.

Country	Year								
	1983	1984	1985	1986	1987	1988	1989	1990	1991
	--Metric tons (live weight)--								
China	9,000	19,300	40,700	82,800	153,300	199,400	175,000	150,000E	145,000E
Indonesia	39,000	43,000	50,000	53,000	73,000	96,000	97,000	120,000E	140,000E
Thailand	11,600	13,000	15,800	17,900	23,600	55,600	93,500	100,000E	110,000E
India	13,000	15,000	17,000	18,000	22,000	25,000	25,000	30,000E	35,000E
Taiwan	16,800	20,700	32,700	70,000	114,500	43,700	32,300	30,200	30,000E
Vietnam	-	-	13,000	18,000	20,000	22,000	22,000	30,000E	30,000E
Philippines	12,100	28,900	29,000	31,100	35,800	44,900	47,900	54,000	30,000E
Bangladesh	4,400	7,600	14,700	14,700	14,800	16,600	18,200	23,100E	25,000E
Burma	-	7	10	500	4,000E	4,000E	4,000E	4,000E	4,000E
Japan	2,000	2,000	2,200	2,400	900	3,000	2,800	3,000	3,500E
Malaysia	400	100	200	300	800	1,300	2,200	2,500E	2,500E
Australia	-	-	15	28	26	200	500	600	1,100E
Sri Lanka	-	-	100	400	400	700	700	800E	800E
Korea, South	50	100	100	100	200	200	300	300	300E
New Caledonia	-	20	40	65	100	200	400	500E	500E
Singapore	54	64	100	100	100	100	100	50E	50E
Fiji	-	17	20	7	8	8	7	7E	7E
Pakistan	-	-	1	8	-	44	22	-	-
New Zealand	-	-	-	-	-	-	9	-	-
Total	108,400	149,800	215,800	309,400	465,500	512,900	521,900	549,100E	557,800E

E - Estimate
Sources: FAO Yearbook of Fishery Statistics, World Shrimp Farming, and various country sources.

Appendix C.--**Asia.** Glossary of major cultured shrimp species.

Scientific Name	FAO English Name	Local names
Penaeus indicus	Indian white prawn	Jaira/Jiaro (Pakistan); Jinga (India); Chapra chingri (Bangladesh); Udang putih (Indonesia); Hipon putih (Philippines);
P. japonicus	Kuruma prawn	Kuruma-ebi (Japan); Kalri (Pakistan); Flowery prawn (Hong Kong); Banded shrimp (Taiwan); Oriental brown shrimp(Korea)
P. merguiensis	Banana prawn	Jaira/Jiaro (Pakistan); Udang kaki merah (Malaysia); Udang putih (Indonesia); Kung chaebauy (Thailand); Pak ha (Hong Kong)
P. monodon	Giant tiger prawn	Jinga/Yera (India); Ushi-ebi (Japan); Kalri (Pakistan); Grass shrimp (Taiwan); Sugpo (Philippines); Udang windu(Indonesia)
P. orientalis*	Fleshy prawn	Taisho-ebi/Korai-ebi (Japan)
P. penicillatus	Redtail prawn	Jaira, Jiaro (Pakistan), Pak ha, White prawn (Hong Kong); Red-tailed prawn (Taiwan)
P. semisulcatus	Green tiger	Kalri (Pakistan); Kuma-ebi (Japan); prawn Fa ha/Flower prawn/Bamboo prawn (Hong Kong); Kung kula lai (Thailand)
Macrobrachium rosenbergii	Giant river prawn	Bharo/Chooan chingri (Bangladesh); Udang satang/duri (Indonesia); Golda/Mocha chingri (India); Koong yai (Thailand)
Metapenaeus ensis	Greasyback shrimp	Udang laki (Indonesia); Yosi-ebi (Japan); Sand shrimp (Taiwan); Chung ha (Hong Kong); Kung takard (Thailand)

* - Also referred to as P. chinensis.
Source: FAO Species Catalog: Vol. 1-Shrimps and Prawns of the World, FIR/S125 Vol. 1, 1980.

Appendix D.--**Australia.** Total shrimp production, by fishery, with cultured harvest as a percentage of total shrimp production, 1983-91.

Year	Fishery			Percent
	Wild Catch	Cultured	Total	
	--Metric tons--			--In percent--
1983	21,649	0	21,649	0
1984	22,731	0	22,731	0
1985	20,520	15	20,535	0.1
1986	18,472	28	18,500	0.2
1987	20,774	26	20,800	0.1
1988	22,362	238	22,600	1
1989	18,930	470	19,400	2
1990	16,406	594	17,000	3
1991	N/A	1,100E	N/A	

E - Estimate
Sources: 1983-89, FAO Yearbook of Fishery Statistics; 1990-Australian Fisheries Service

Appendix E.--**Bangladesh.** Total shrimp production, by fishery, with cultured harvest as a percentage of total shrimp production, 1983-91.

Year	Fishery			Percent
	Wild Catch	Cultured	Total	
	--Metric tons--			--In percent--
1983	19,788	4,386	24,174	18
1984	25,788	7,578	33,366	23
1985	34,820	14,658	49,478	30
1986	0	14,700	14,700	100
1987	0	14,800	14,800	100
1988	0	16,600	16,600	100
1989	35	18,200	18,235	99
1990	3,382E	23,100E	26,482E	87
1991	N/A	25,000E	N/A	

E - Estimate.
Sources: U.S. Embassy, Dhaka, January 30, 1986, June 24, 1987, and August 26, 1991; FAO Yearbook of Fishery Statistics, World Shrimp Farming.

Appendix F.--**Burma.** Total shrimp production, by fishery with cultured harvest as a percentage of total shrimp production, 1983-91.

Year	Fishery			Percent
	Wild Catch	Cultured	Total	
	--Metric tons--			--In percent--
1983	4,400	N/A	4,400	N/A
1984	5,200	7	5,207	Negl.
1985	6,900	10	6,907	Negl.
1986	3,000E	4,000E	7,000E	57
1987	3,000E	4,000E	7,000E	57
1988	3,000E	4,000E	7,000E	57
1989	3,000E	4,000E	7,000E	57
1990	3,000E	4,000E	7,000E	57
1991	N/A	4,000E	N/A	

Negl. - Negligible.
E - Estimate.
Sources: American Embassy, Rangoon, January 27, 1986, May 11 and May 18, 1987, and October 7, 1991; FAO Yearbook of Fishery Statistics.

Appendix G.--**China.** Total shrimp production, by fishery, with cultured harvest as a percentage of total shrimp production, 1983-91.

Year	Fishery			Percent
	Wild Catch	Cultured	Total	
	--Metric tons--			--In percent--
1983	211,500	9,000	220,500	4
1984	230,100	19,300	249,400	8
1985	326,200	40,700	366,900	11
1986	343,800	82,800	426,600	19
1987	304,200	153,300	457,500	34
1988	384,200	199,400	583,600	34
1989	327,100	175,000	502,100	35
1990	N/A	150,000E	N/A	
1991	N/A	145,000E	N/A	

E - Estimate.
Sources: Bureau of Aquatic Products, People's Republic of China; FAO Yearbook of Fishery Statistics, World Shrimp Farming.

Appendix H.--**India.** Total shrimp production, by fishery, with cultured harvest as a percentage of total shrimp production, 1983-91.

Year	Fishery			Percent
	Wild Catch	Cultured	Total	
	--Metric tons--			--In percent--
1983	167,000	13,000	180,000	7
1984	192,000	15,000	207,000	7
1985	189,000	17,000	206,000	8
1986	212,000	18,000	230,000	8
1987	200,000	22,000	222,000	10
1988	202,000	25,000	227,000	11
1989	228,000	25,000	253,000	10
1990	N/A	30,000E	N/A	
1991	N/A	35,000E	N/A	

E - Estimate.
Sources: Marine Products Export Development Authority, World Shrimp Farming.

Appendix I.--**Indonesia.** Total shrimp production, by fishery, with cultured harvest as a percentage of total shrimp production, 1983-91.

Year	Fishery			Percent
	Wild Catch	Cultured	Total	
	--Metric tons--			--In percent--
1983	111,000	39,000	150,000	26
1984	101,000	43,000	144,000	30
1985	107,000	50,000	157,000	32
1986	117,000	53,000	170,000	31
1987	140,000	73,000	213,000	34
1988	139,000	96,000	235,000	41
1989	152,000	97,000	249,000	39
1990	N/A	120,000E	N/A	
1991	N/A	140,000E	N/A	

E - Estimate.
Sources: Indonesia Directorate of Fisheries; World Shrimp Farming

Appendix J.--**Japan.** Total shrimp production, by fishery, with cultured harvest as a percentage of total production, 1983-91.

Year	Fishery			Percent
	Wild Catch	Cultured	Total	
	--Metric tons--			--In percent--
1983	62,400	2,000	64,400	3
1984	61,000	2,000	63,000	3
1985	52,000	2,200	54,200	4
1986	45,500	2,400	47,900	5
1987	45,500	2,900	48,400	6
1988	46,400	3,000	49,400	6
1989	42,200	2,800	45,000	7
1990	41,000	3,000	44,000	7
1991	N/A	3,000E	N/A	

E - Estimated.
Sources: Ministry of Agriculture, Forestry, and Fisheries; World Shrimp Farming.

Appendix K.--**Republic of Korea.** Total shrimp production by fishery, with cultured harvest as a percentage of total production, 1983-91.

Year	Catch			Percent
	Wild	Cultured	Total	
	--Metric tons--			--In percent--
1983	38,606	50	38,656	0.1
1984	31,717	93	31,810	0.3
1985	40,775	84	40,859	0.2
1986	45,221	133	45,354	0.3
1987	48,199	201	48,400	0.4
1988	49,619	181	49,800	0.4
1989	51,098	302	51,400	0.6
1990	58,398	312	58,710	Negl.
1991	N/A	300E	N/A	

E - Estimate
Negl. - Negligible.
Sources: ROK National Fisheries Administration, Ministry of Agriculture and Fisheries; American Embassy, Seoul, November 5, 1991.

Appendix L.--**Malaysia.** Total shrimp production, by fishery, with cultured harvest as a percentage of total shrimp production, 1983-91.

Year	Fishery			Percent
	Wild Catch	Cultured	Total	
	--Metric tons--			--In percent--
1983	52,821	415	53,236	1
1984	64,566	127	64,693	0.1
1985	67,746	205	67,950	0.1
1986	72,076	349	72,425	0.1
1987	84,596	765	85,361	0.1
1988	83,608	1,325	84,933	1.6
1989	106,842	2,198	109,039	2.1
1990	N/A	2,460	N/A	
1991	N/A	2,500E	N/A	

E - Estimate
Source: Department of Fisheries, Malaysia.

Appendix M.--**Pakistan.** Total shrimp production, by fishery, with cultured harvest as a percentage of total shrimp production, 1983-91.

Year	Fishery			Percent
	Wild Catch	Cultured	Total	
	--Metric tons--			--In percent--
1983	27,502	-	27,502	0
1984	28,570	-	28,570	0
1985	26,874	1	26,873	Negl.
1986	26,792	8	26,800	Negl.
1987	29,900	-	29,900	0
1988	29,356	44	29,400	Negl.
1989	23,478	22	23,500	Negl.
1990	27,900	-	27,900	Negl.
1991	N/A	-	N/A	

Negl. - Negligible.
Sources: American Consulate, Karachi, Pakistan, August 22, 1991; Marine Fisheries Department, Government Ministry of Food, Agriculture, and Cooperatives, Pakistan.

Appendix N.--**Philippines.** Total shrimp production, by fishery, with cultured harvest as a percentage of total shrimp production, 1983-91.

Year	Fishery			Percent
	Wild Catch	Cultured	Total	
	--Metric tons--			--In percent--
1983	17,600	12,100	29,700	40
1984	15,500	28,900	44,400	65
1985	15,500	29,000	44,500	65
1986	22,800	31,100	53,900	58
1987	17,600	35,800	53,400	67
1988	17,800	44,900	62,700	72
1989	17,600	47,900	65,500	73
1990	14,100	54,000	68,100	79
1991	N/A	30,000E	N/A	

E - Estimate.
Sources: U.S Embassy, Manila; April 30, 1986, May 5, 1987, and November 15, 1991, World Shrimp Farming.

Appendix O.--**Singapore.** Total shrimp production, by fishery, with cultured harvest as a percentage of total shrimp production, 1983-91.

Year	Fishery			Percent
	Wild Catch	Cultured	Total	
	--Metric tons--			--In percent--
1983	N/A	N/A	1,667	N/A
1984	2,179	40	2,219	1
1985	1,925	85	2,010	4
1986	1,838	118	1,956	6
1987	1,401	106	1,507	7
1988	908	72	980	8
1989	736	59	795	8
1990	N/A	50E	N/A	
1991	N/A	50E	N/A	

E - Estimate
Source: FAO Yearbook of Fishery Statistics

Appendix P.--**Sri Lanka.** Total shrimp production, by fishery, with cultured harvest as a percentage of total shrimp production, 1983-91.

Year	Fishery			Percent
	Wild Catch	Cultured	Total	
	--Metric tons--			--In percent--
1983	4,017	0	4,017	0
1984	4,655	0	4,655	0
1985	4,731	89	4,820	2
1986	3,600	400	4,000	10
1987	3,800	400E	4,200E	10
1988	3,080	670E	3,750E	18
1989	N/A	700E	N/A	
1990	N/A	800E	N/A	
1991	N/A	800E	N/A	

E - Estimate.
Sources: U.S Embassy, Colombo, February 14, 1987, and August 8, 1991.

Appendix Q.--**Taiwan.** Total shrimp production, by fishery, with cultured harvest as a percentage of total shrimp production, 1983-91.

Year	Fishery			Percent
	Wild Catch	Cultured	Total	
	--Metric tons--			--In percent--
1983	72,763	16,800	89,563	12
1984	81,512	20,700	102,212	13
1985	75,903	32,700	108,603	18
1986	68,705	70,000	138,705	37
1987	61,200	114,500	175,700	65
1988	67,700	43,700	111,400	39
1989	68,400	32,300	100,700	32
1990	48,100	30,200	78,300	39
1991	N/A	30,000E	N/A	

E - Estimate.
Sources: American Institute in Taiwan, Taipei, April 29, 1987; Council of Agriculture; World Shrimp Farming.

Appendix R.--**Thailand.** Total shrimp production, by fishery, with cultured harvest as a percentage of total shrimp production, 1983-91.

Year	Fishery			Percent
	Wild Catch	Cultured	Total	
	-Metric tons--			--In percent--
1983	127,600	11,600	139,100	8
1984	104,400	13,000	117,400	11
1985	91,600	15,800	107,500	15
1986	102,500	17,900	120,400	15
1987	106,200	23,600	129,800	18
1988	85,900	55,600	141,500	39
1989	85,200	93,500	178,700	52
1990	N/A	100,000	N/A	
1991	N/A	110,000E	N/A	

E - Estimate.
Sources: Department of Fisheries, Thailand; World Shrimp Farming.

Appendix S.--**Vietnam.** Total shrimp production, by fishery, with cultured harvest as a percentage of total shrimp production, 1983-91.

Year	Fishery			Percent
	Wild Catch	Cultured	Total	
	-Metric tons--			--In percent--
1983	N/A	N/A	49,100E	N/A
1984	N/A	N/A	52,000E	N/A
1985	41,100	13,000	54,100E	24
1986	37,600	17,800	55,400E	32
1987	36,000	20,000	56,000E	36
1988	34,000	22,000	56,000E	39
1989	33,000	22,000E	55,000E	40
1990	N/A	30,000E	N/A	
1991	N/A	30,000E	N/A	

E - Estimate.
Source: FAO Yearbook of Fishery Statistics, World Shrimp Farming.

3.1

CHINA

China is the world's leader in the production of farm-raised shrimp. Chinese shrimp growers, assisted by a thorough, long-term government program and economic reforms, have massively increased harvests during the 1980s. In 1990, harvests declined from the record levels of 1988, but still exceeded 150,000 metric tons for the fourth straight year. China has led the world in both the total harvest of cultured shrimp and the production of artificially-reared shrimp seedstock since 1986. China's rapid increase in cultured shrimp production has been mainly based on the development of hatchery and pond management technology. The country's manpower resources are enormous and will be an important factor in the continued growth of the cultured shrimp industry. Shrimp culture has provided China a valuable export commodity with the majority of its exports going to Japan and the United States. Chinese growers, however, face a variety of pressing problems which may impede future expansion.

CONTENTS

I. OVERVIEW

A. Harvests

Before 1950: Although shrimp culture in China is hundreds of years old, modern shrimp farming techniques have developed only recently. Before the 1950s, shrimp farming was primarily based on traditional methods of shrimp/fish polyculture. In Northern China, local species of shrimp and mullet were raised together. In Southern China, white shrimp, such as *Penaeus merguiensis (P. merguiensis)* and/or *P. penicillatus*, and grey mullet were stocked in ponds. Growers employed basic extensive methods. Juveniles and postlarvae were raised with inflowing water collected during high tides. During growout, nutrients consisted of what was present in the inflow water. Therefore, yield was low and inconsistent. Research was conducted to improve these traditional methods.

1950-1980: The Chinese Communist Government initiated limited research focusing on growing *P. chinensis* under controlled conditions beginning in

Figure 1. *Coastal China and its provinces.*

the early 1950's. Chinese shrimp culture developed slowly before the mid 1970s, however, because of minimal government support and low profits.[1] The Chinese actually succeeded in culturing shrimp for the first time in 1960, but did not begin to commercially raise shrimp until 1978. The transition from experimental to commercial harvest began in 1979, when a government shrimp culture enterprise was set up in the port city of Lianyungang (Jiangsu Province), on the Yellow Sea coast (figure 1). About 1,250 metric tons (t) of cultured shrimp were commercially harvested in 1979. Although some growers began to experiment with semi-intensive methods, most employed extensive methods during these early years. Shrimp were typically cultured in old salt ponds, coastal inlets, or natural ponds, and production per hectare (ha) was low. Polyculture with other fish species was the norm. One observer estimates that in 1976 only 7,200 ha were devoted to shrimp culture.

1980s: The Chinese Fisheries Bureau first succeeded in commercially culturing *P. chinensis* in the city of Tianjin (located southeast of Beijing on the Bohai coast-figure 1) around 1980. After this initial success, pond construction expanded rapidly. Cultured shrimp harvests began to grow rapidly after 1983, when the area devoted to shrimp culture reached almost 20,000 ha, and harvests totaled about 9,000 t (appendices B and C). By 1988, the area under shrimp aquaculture had grown to over 240,000 ha, with harvests of nearly 200,000 t (appendix A)--increases of 1,200 percent and 2,200 percent respectively (appendices B and C).

B. Species

The most important cultured species in China is *P. chinensis* (also known as *P. orientalis* or Chinese white shrimp), a species adapted to cool, northern waters. This species is cultured primarily in the Yellow Sea and East China Sea coastal regions. The Chinese success with *P. chinensis* is an anomaly as other successful shrimp culture industries use tropical species. The Chinese industry is the only major shrimp culture industry conducted in temperate latitudes. *P. chinensis* accounts for the lion's share of China's harvest--80-90 percent of the total. *P. chinensis* characteristically has a high-quality white flesh and grows to the large sizes preferred by most export markets. In addition to P. chinensis, tropical and subtropical species such as *P. japonicus* (kuruma prawn), *P. merguiensis* (banana prawn), *P. monodon* (giant or black tiger prawn),

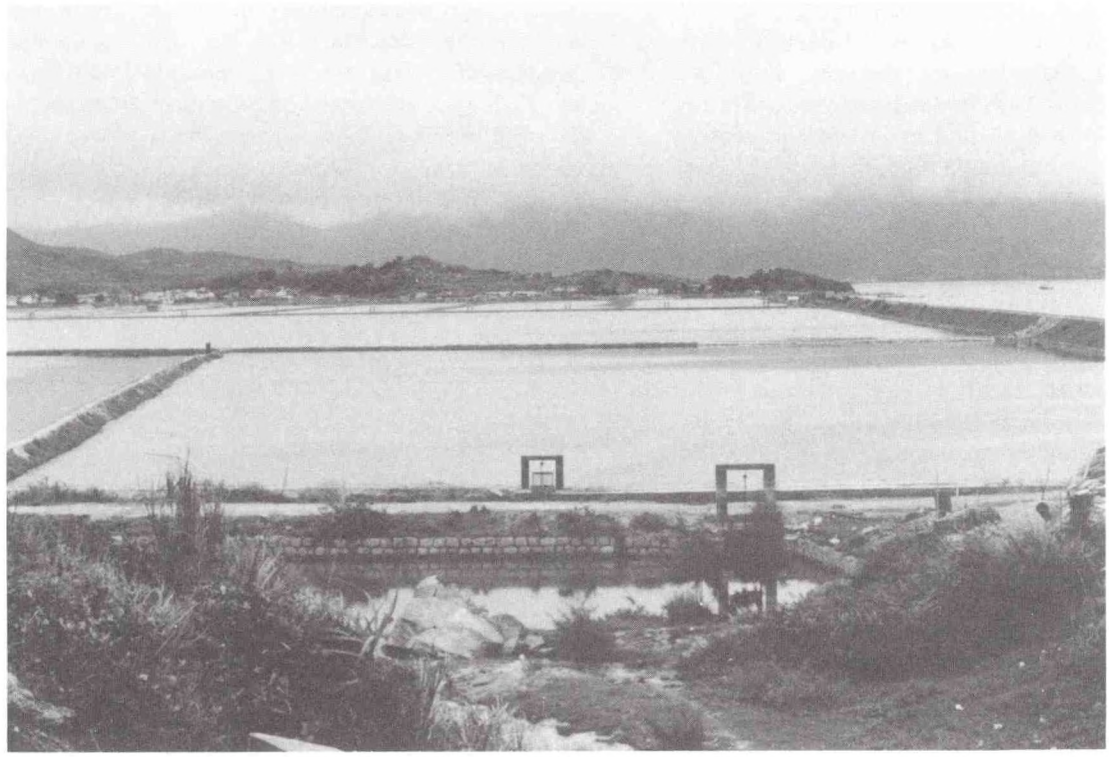

***Photo 1.**--Shrimp farm near Qingdao, Shandong Province. ©William D. Chauvin*

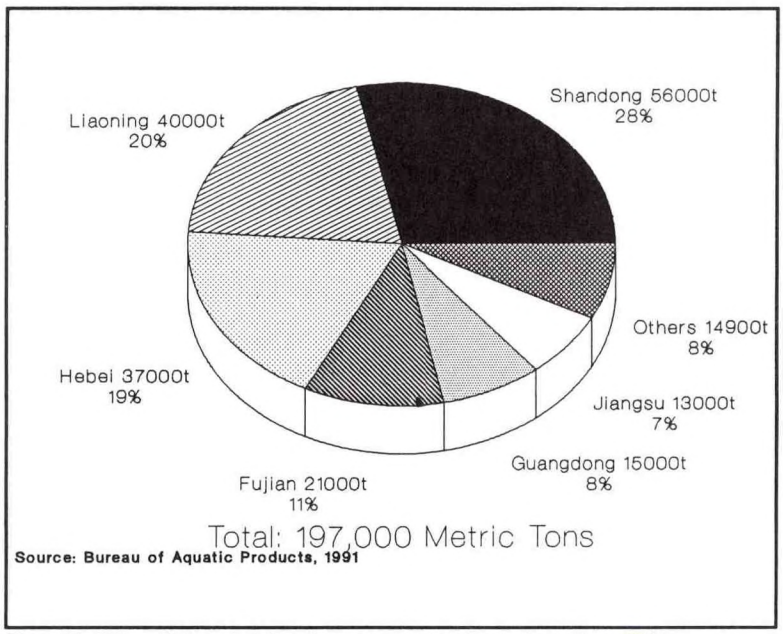

Figure 2. China. Cultured shrimp harvests, by quantity and province, 1988.

and *P. penicillatus* (redtail prawn) are cultured in Southern China.

C. Provinces

The provinces in China that harvest the greatest quantities of cultured shrimp are found along the country's 18,000 kilometer coast. *P. chinensis* prefer cooler water temperatures and are therefore cultured almost exclusively in the northern provinces around the Bohai Gulf and bordering the Yellow Sea--Liaoning, Shandong, Hebei, Jiangsu, and Zhejiang (figure 1).

Northern China: In the north, shrimp are harvested in September, while in central provinces, they are harvested at the beginning of October. The 4½ month growing season combined with low water temperatures in the northern regions, result in the harvest of mostly smaller-sized shrimp. The major size groups by quantity are 41/50, 31/40, 51/60, and 61/70.

The climate in the north is temperate and the winter season is long and cold. Consequently, shrimp can only be cultured for 4-5 months of the year, a distinct disadvantage in comparison with other major shrimp-harvesting countries in Asia. This short growing season permits the harvest of only one crop per year. Shandong is the shrimp culture industry's key province in Northern China, harvesting over 56,000 t of cultured shrimp in 1988 (appendix C and figure 2). This harvest accounted for over 25 percent of China's total 1988 cultured shrimp harvest and represents a spectacular increase from the negligible amounts harvested at the beginning of the decade (appendix C). Liaoning Province was the next largest, harvesting over 40,000 tons of cultured shrimp. Hebei and Jiangsu Provinces produced approximately 37,000 t and 13,000 t, respectively, in 1988 (figure 2). The northern part of Fujian Province constitutes the southern biological limit for *P. chinensis*.

Southern China: The warm southern coastal waters of the South China Sea are more suitable for the culture of tropical and subtropical shrimp species which characterize the shrimp culture industry in most other countries. Chinese growers in these areas, however, have made only minor progress in developing the region's potential. Growers in the southern half of Fujian, and all of Guangdong and Guangxi Provinces primarily harvest *P. merguiensis*. However, *P. merguiensis* are not differentiated from *P. chinensis* in Southern China, and there is consequently much mixing of the two species when exported in block form. Although production is still small, *P. monodon* culture is increasing in the southern provinces, particularly Guangdong and Fujian. Large areas of the coast seem suitable for shrimp culture. The major limiting factor appears to be the availability of postlarval seedstock. This suggests that China has significant potential to expand its harvests.

II. GOVERNMENT ASSISTANCE

A. Aquaculture

The startling growth in cultured shrimp harvests is the result of the Chinese Government's overall emphasis on aquaculture. Aquaculture is seen as the key to China's goal of raising fisheries production to 18 million t by the year 2000. According to Chinese press reports, the government originally expected catch to increase by about 0.4 million t yearly, primarily as a result of expanding aquaculture harvests. China has far exceeded this estimate since 1985, however, with its annual catch

increasing by nearly 1.0 million t each year. The 9.4 million t 1987 catch already exceeded China's 1990 goal of 9 million tons. China's 1990 catch is reportedly over 12 million t, making China the world's largest fishing country.

B. Shrimp Culture Programs

Most of China's aquaculture research and promotion has been directed at expanding harvests of carp and a variety of low-value species for domestic consumption. Government planners, however, have also promoted shrimp culture to increase export earnings. Specific government measures to support shrimp culture include:

1. Playing an active role in accelerating development of the industry in its initial stages through planning, organizing, and coordinating various aspects, including production, processing, and trade.

2. Allowing foreign exchange earned from shrimp exports to be used by growers instead of turning it over to the state. In addition, shrimp products were tax exempt for the years 1979-1984.

3. Allocating more than $20 million in grants and releasing a large sum of development loans at low interest rates during 1979-1985.

4. Initiating a highly respected nationwide research program, with the cooperation of more than 10 institutes, universities, and farms. The research emphasizes seed production, feed and nutrition, diseases, and farm management systems. Extension work has also been strengthened to facilitate technology transfer.[2]

C. Research Facilities

In China there are nine fisheries research institutes supervised by the Chinese Academy of Fishery Sciences. Of these, three are marine institutes, four are freshwater institutes, one is a machinery and instrument institute, and one is an engineering institute. Coordination of fisheries research is carried out through the Scientific and Technology Department of the Bureau of Aquatic Products, Ministry of Agriculture.

Major provinces and cities also have fisheries research institutes which conduct applied research, and are supervised by the provincial or municipal bureau of aquatic products. For example, the Institute of Oceanology in Shandong Province is working on marine shrimp culture. The Yellow Sea Fisheries Institute is also working on marine shrimp culture and has a unit dealing with processing cultured harvests. In Shanghai, the East China Sea Fisheries Research Institute is actively pursuing studies in marine shrimp culture. At the Marine Hot Springs Aquaculture Development Center in Fujian province, marine shrimp are maintained in geothermal waters under both experimental and production conditions. Research on freshwater prawn culture is taking place at the Freshwater Aquaculture Institute in Fujian province.[3]

Many shrimp growers are currently requesting that scientists provide them with new species with high growth rates, disease resistance, and adaptability to various environmental conditions. Therefore, experiments on breeding new varieties by hybridization or sex control (all female shrimp breeding), are now being conducted. Scientists are attempting to identify shrimp species which grow rapidly at high densities to maximize yields. Scientists are also conducting various artificial breeding experiments on those species to improve yields.

Chinese researchers paid little attention to shrimp diseases until the mid-1980s because diseases were limited to certain areas and losses were not serious. Disease losses are now mounting. In addition, growers note the problems experienced in Taiwan, Thailand, and other countries. The government has conducted shrimp disease surveys in most coastal provinces, particularly in Southern China. Disease tends to be more prevalent in southern provinces since water temperatures are higher. Microbiological studies have been carried out and methods for disease control have been developed. Studies on viral and fungal diseases are now beginning.[4]

D. Management Reforms

Major reforms of China's state-controlled economy have helped promote the shrimp culture industry. One of the most important is the fishery contract responsibility management system. Under this system, the government retains title to ponds and infrastructure, but contracts with a group of households, a single household, or an individual, for specified production at a given price. After fulfilling their government contract, contractees are permitted to keep profits from sales of any remaining production. Many villages and households have become very wealthy through

shrimp culture. The average revenue per pond ha was about $1,800 in 1987. Other important reforms included a liberal production policy which allows farm households to control procurement of farm inputs and marketing of the product, and relaxation of the conditions for the purchase and marketing of aquatic products.

The Chinese Government is currently providing further financial backing for increases in fisheries production, especially in aquaculture. The government has approximately $29.6 million for the development of the fishing industry and the construction of processing plants, technical renovation, and fish feed production. The Chinese Government hopes to double aquaculture harvests every 3 years. Consequently, pond construction is underway in most coastal areas. The government has also permitted joint ventures with foreign investors to obtain needed capital. One example is an agreement with Thailand's agribusiness giant, the **Charoen Pokphand Group** (CP). CP is preparing major shrimp joint ventures in Hainan, China, modeled after its farms in Thailand. CP will provide needed credits and shrimp seedstock to Chinese growers on a contract basis.

III. METHODS

Shrimp growers use three major methods: (1) extensive, (2) semi-intensive, and (3) intensive. **Extensive** farming is a traditional method. Ponds are generally 10-100 ha in size and water exchange depends on natural tidal fluctuation. Production with this method is low, generally 0.2-0.3 t per ha. **Intensive** culture offers higher yields (as much as 7-10 t per ha), but the high cost of pumps and energy has limited the use of this technique. Consequently, most shrimp growers in China use **semi-intensive** methods. This technique employs ponds with a size of 3-4 ha in area, and 1-2 meters (m) in depth. The average stocking rate in China's semi-intensive shrimp ponds ranges from 150,000-300,000 pl per ha. To improve water quality, water pumps are widely used to move seawater during weak tidal periods. Windpower is generally used to aerate semi-intensively cultured ponds, but air blowers and paddles have been introduced in the late 1980s.[5]

A. Northern China

The methods employed by Chinese growers vary with region and species. In Northern China, the growout ponds of most shrimp farms are earthen, typically about 2 to 10 ha in size and 1.5 to 2 m deep. Most of the ponds in **Hebei** and **Liaoning** Provinces are small (2-3 ha), constructed in the 1980s, and equipped with pumping systems for water exchange. The growout ponds here are bigger than those found in Southeast Asian countries and the operation is mainly semi-intensive.

Farther south in **Shandong** and **Jiangsu** Provinces, shrimp ponds are larger (4-7 ha) and usually not more than 1 m deep. Most are equipped with pumping systems rather than aerators. A few extensive ponds there are very big (over 20 ha).[6]

B. Southern China

Conditions are favorable for tropical shrimp culture in Southern China, especially **Guangdong** Province. Currently, Guangdong's extensive culture farms harvest about 0.5 t per ha, while the semi-intensive farms produce about 0.6-0.8 t per ha. Shrimp culture is generally practiced on a small-scale in Guangdong Province. Whereas other ponds in China may be as large as 10 ha, the Guangdong Province Fishery Development Corporation builds shrimp ponds with an average size of 0.6 ha and allocates one pond to each family. The family takes total financial responsibility for the shrimp culture operation and sells the Corporation its production at a fixed price.

IV. FEEDS

Chinese production costs are touted to be the lowest in the world (about $2 per kg) with shrimp feed representing 50-75 percent of total production costs. Most shrimp feeds in China consist of trash fish and marine shellfish combined with formulated feeds at small mills. Mussels and blue clams are often used as a supplemental feed. Other feeds utilized are earthworms, insects, small shrimps and crabs, and peanut or soybean cake. Formulated shrimp feed, made from a mixture of fish meal, yeast, activated starch, and a number of other agricultural by-products, has a much higher feed/flesh conversion ratio than does peanut/soybean cake or trash fish--3/1 versus 4/1 and 12/1, respectively. The main drawback is the relatively high cost of the formulated feeds.

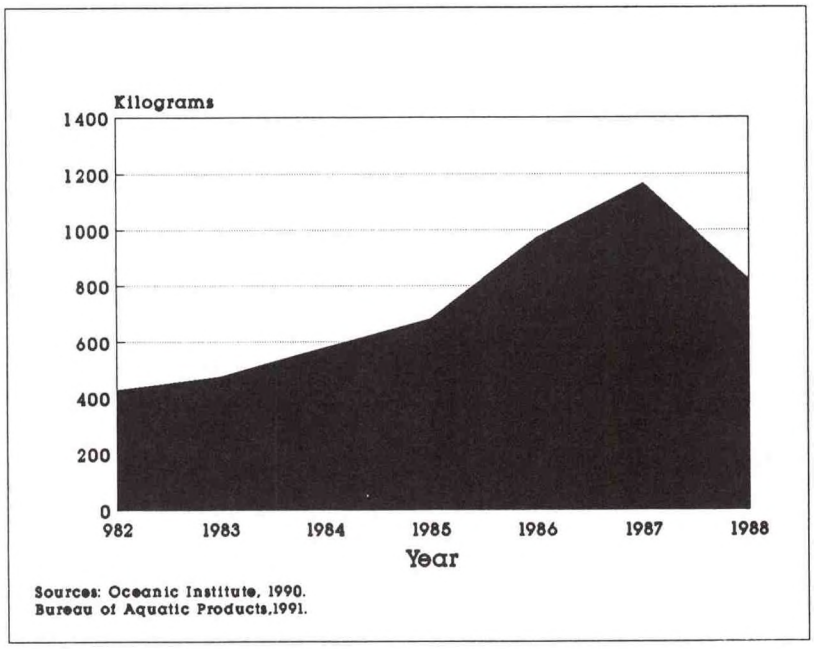

Figure 3. China. Average yield of cultured shrimp per hectare, 1982-88.

China's need to expand and improve feed production has resulted in efforts to form joint ventures with important foreign feed companies. The Norwegian Trouw International Corporation opened the first of several planned shrimp feed mills in China during August 1989. The mill will operate under the name Sulandlink and is a joint venture between Trouw, the Jiangsu Company of China, and Paclink of Hong Kong.

V. YIELDS

Chinese growers made great progress in increasing average yield per ha during the mid-1980s, from slightly more than 0.4 t per ha in 1982 to about 1.2 t per ha in 1987 (figure 3).

Average yield dropped to 0.8 t per ha in 1988, however, indicating yields in China may be levelling off. Average yields differ markedly between the various coastal provinces. Of the major shrimp-producing areas, Hebei Province in 1988 had the highest yield, averaging 1.4 t per ha. Liaoning and Fujian Provinces were second in average yield, both reporting 0.9 t per ha. Other provinces report comparatively low yields, particularly southern provinces such as Guangxi and Guangdong, because of the predominance of extensive farms. Efforts to increase yields are organized largely at the provincial level.

VI. HATCHERIES

China had no commercial shrimp hatcheries throughout most of the 1970s. Shrimp growers, before 1978, relied on wild post-larvae (pl) for seedstock. As a result, the pl supply was affected by unpredictable environmental factors, and the cultured shrimp harvests fluctuated annually. The shrimp culture industry underwent a dramatic change in 1978 when the first successful hatchery opened and began to supply pl on a regular basis to farms.

Recent reports estimate that there are nearly 300 Chinese shrimp hatcheries supplying pl from 70 percent wild and 30 percent captive females. The

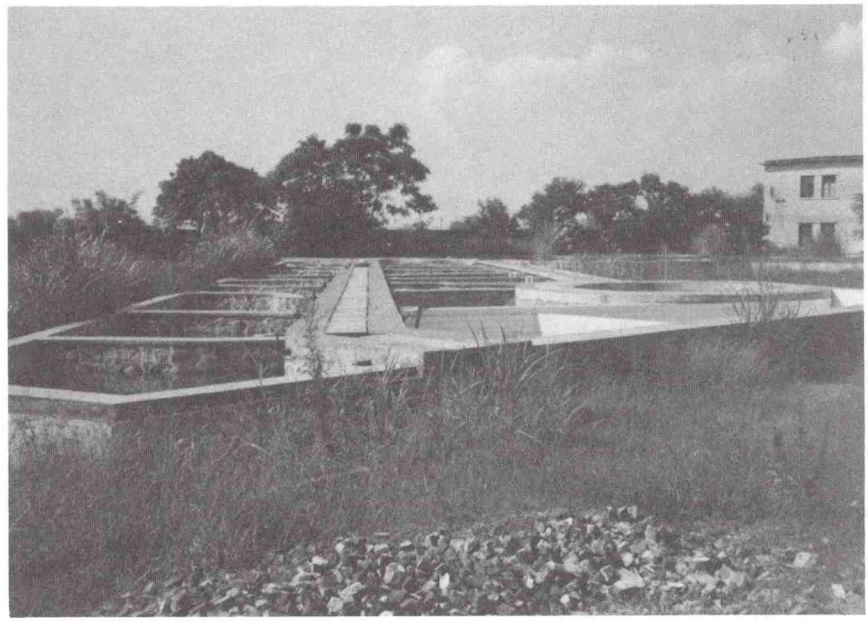

Photo 2--Chinese shrimp hatchery. © Henry R. Branstetter

Chinese Government, to protect natural stocks, required that all seed stock be produced from captive females by the end of 1990. As a result, joint ventures are being encouraged to increase the supply of postlarvae. An example is the Zhousan Second Fishery Corporation in Zhejiang Province which established a joint venture with Japan's Taiyo Fisheries Company in 1986. The venture produced 10 million shrimp pl for Zhejiang ponds during the first year of operation.

Chinese hatcheries use two main methods to produce pl seedstock. **Mature spawners:** fishermen collect mature spawners on fishing grounds. After delivery to the hatcheries, the pl are produced within a few days. This is the main source of seedstock in Northern China. The advantage of this method is that it avoids the expense of building a sophisticated maturation hatchery. This method, however, leaves the farmers subject to the same environmental and climatic fluctuations that affect pl availability in the wild.

Maturation: A second source of seedstock consists of broodstock taken from the wild or reared in ponds. In the north, healthy adult shrimp of both sexes are selected and kept in controlled-temperature nursery ponds. The artificially controlled conditions allow them to mature between February and April in the cold northern climate. In the south, the natural water temperature is high enough to permit broodstock to be held in outdoor nursery ponds As a result, this method is much more widely used in the south than in the north.

The Chinese Government operates most hatcheries. Almost all of them are relatively large facilities capable of producing hundreds of millions of pl annually. A few private groups opened hatcheries during the late 1980s modeled after backyard hatcheries in Thailand. Because of a lack of necessary knowledge and hatchery techniques, these private owners often invite technicians or experts from Chinese fisheries research institutions to be their technical consultants.

Large rearing tanks (10-50 cubic meters) and high densities (100,000-200,000 pl/cubic meter) are generally used in both northern and southern parts of China. For climatic reasons, all hatchery facilities in the northern provinces are indoors. The hatching season extends from April to early June in Liaoning, Hebei, Shandong, and Jiangsu Provinces. In contrast, in Guangdong and Hainan Provinces, most of the facilities are outdoors and have a longer hatching season (February to July). *P. chinensis* larvae are raised in the early part of the season and *P. merguiensis* larvae are cultured in the latter part of the season. [7]

VII. MARKETING

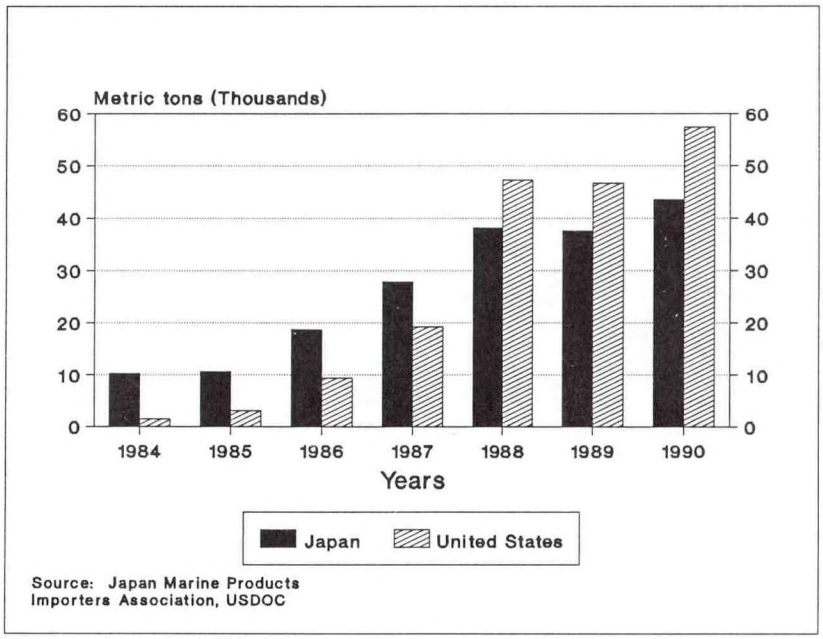

Figure 4. China. Total shrimp exports to Japan and the United States, by quantity, 1990.

China in 1982 was only a minor participant in the international shrimp market, but has now become the world's leading exporter. China is the principal exporter of shrimp to the United States and the second largest exporter to Japan, benefiting from the collapse of Taiwan's production in 1988. These declines have created important opportunities in both the U.S. and Japanese markets. The United States and Japan accounted for nearly 90 percent of China's shrimp exports in 1988 (figure 4). China exported an estimated 98,200 t of shrimp in 1988, valued at nearly $600 million--about 60 percent of the total value of China's fishery exports for the year (app. D).

Chinese shrimp exports were controlled by the China National

Cereals, Oils, and Foodstuffs Import and Export Corporation until the mid 1980s. Economic reforms have now given provincial corporations the power to export directly. This has opened the door for additional firms wanting to export, but has also pitted the Chinese ministry handling foreign trade against provincial trading firms and manufacturers allowed to trade with foreigners. The shrimp culture industry was given a powerful impetus when the government decided to allow exporters to keep a percentage of the foreign exchange receipts.

A. Processing

China has about 1,400 shrimp processing plants. They process both captured and cultured shrimp as well as other aquatic products. These plants have a freezing capacity of 1,800 t per day and a cold storage capacity of 53,600 tons. Shrimp processing plants and cold storage facilities are located near farms or fishing harbors. Head removal, peeling, quick freezing, packing, and cold storage are all completed in the plants. Most of the processing plants have ice-making capability. Processed headless shrimp are usually packed as 2 kg frozen blocks.

Seasons: China's shrimp harvest is processed for export primarily in the last quarter of the year because both the important northern cultured harvest and the wild shrimp fishing seasons occur at this time.[8] Because of the lack of cold stores, the policy in the past has been to ship the shrimp to export markets as quickly as possible. Releasing such a large amount of shrimp at one time has adversely affected market prices not only for Chinese shrimp, but also for shrimp from other countries. This problem is becoming less important as China builds more cold storage facilities and develops the ability to spread out export shipments and temper price fluctuations.

Brands: Chinese exporters ship shrimp under only a few brand names, each of which may be used by a large number of different processing plants. The practice has impaired China's ability to improve product quality. Most managers have little incentive to produce better quality packs when there are no price incentives for their efforts. Cultured shrimp are marketed in the United States under the brand names "Triple A" and "Sea Brand," whereas wild-harvested shrimp are packed under the "Sea Swallow" and "Billow" brands.

Quality Control: Government regulations ensure quality control at processing plants. Specific stipulations regarding quality control are drawn up in each province or city. Local units managing the exports of aquatic products use two methods of quality control. One method uses inspectors who travel from plant to plant, while the second method stations inspectors at designated plants. Every shrimp processing plant must be registered at the National Bureau of Commodity Inspection, which is responsible for issuing licenses after inspecting plant equipment and sanitation. The quality of shrimp processing varies significantly from plant to plant. Problems include: limited processing capacity, outdated processing equipment, and undereducated workers. In particular, plants whose output has been transferred from domestic to foreign markets have difficulties adjusting to the higher standards needed for the export market.[9]

B. The Domestic Market

China's domestic shrimp market has changed substantially. Before 1985, only about 30 percent of the cultured shrimp harvest was consumed domestically. The remainder was exported because of its high foreign-exchange value. Since the Chinese Government rescinded the state control system on the procurement and marketing of shrimp in 1985, domestic sales have increased sharply. Growers in 1988 marketed about 50 percent of their pond harvests in domestic markets.

Shrimp is usually dried for local consumption. China has a limited domestic cold-storage network, and few consumers have home freezers. Annual domestic consumption of shrimp in 1988 was approximately 110 grams per capita. The domestic market could become increasingly important in the future as living standards for the Chinese people improve.

C. Export Markets

1. Japan

China's exports of cultured shrimp to Japan have increased significantly over the past 5 years. Chinese shrimp exports made a fairly major breakthrough in 1988 when the Taiwanese *P. monodon* ("black tiger prawn") crop failure occurred (appendix A). Heavy imports of *P. chinensis* from China compensated for the shortage of P. monodon on the Japanese market. It should be noted,

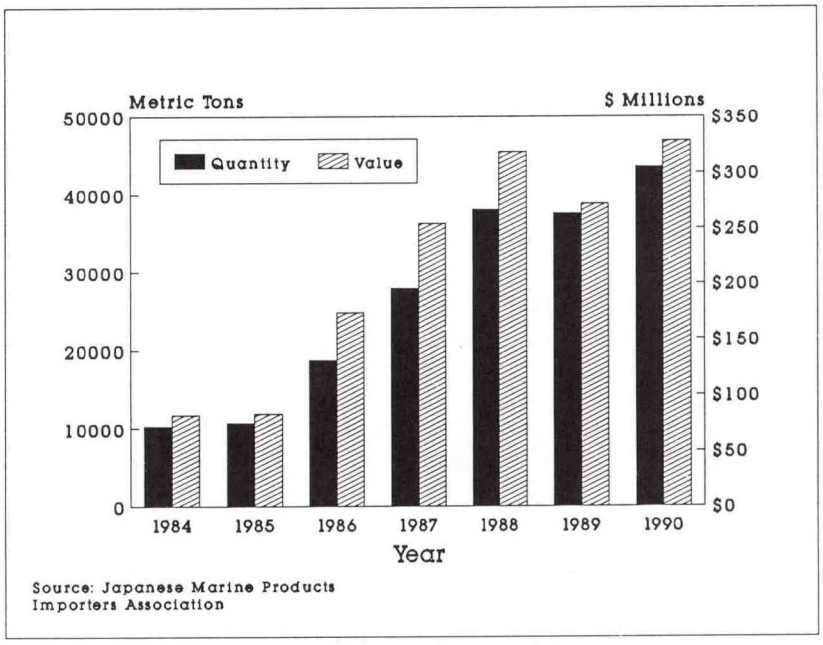

Figure 5. Japan. Imports of Chinese shrimp, by quantity and value, 1984-90.

however, that Chinese exports (as did exports from other countries) levelled off in 1989 because of a drastic price drop resulting from oversupply and reduced demand after the death of the Japanese Showa Emperor. Chinese exports rebounded in 1990 to 44,000 t, over 4 times the 1985 amount (appendix E, figure 5). China, in 1990, advanced to second-place behind Indonesia in the Japanese market as demand returned to pre-1989 levels.

The "trade fairs" purchasing system has traditionally set the Japanese market price for Chinese shrimp. The three most important fairs for the Japanese market are held in Guangdong, Beijing, and Tokyo. Partly because of increasing shrimp production, China is modifying this system. The Guangdong Trade Fair, held biannually (spring and fall), has become less important, while quantities of shrimp contracted at the Beijing and Tokyo Trade Fairs have increased. The latter two trade fairs, which were previously limited in number, have become monthly events in order to facilitate China's export strategy.

2. United States

China initiated significant exports of *P. chinensis* to the U.S. market in 1985. Because traditional shrimp exporters such as Mexico could not meet increasing U.S. demand, U.S. importers increasingly turned to China and other countries, especially as Chinese official prices are below other major suppliers. China overtook Mexico and Ecuador as the foremost shrimp supplier to the U.S. market in 1988. China's total exports of shrimp to the United States rose dramatically between 1985 and 1990, from only 3,100 t to over 57,000 t (appendices F and G, figure 6).

Shell-on frozen shrimp products comprised the vast majority of Chinese exports to the United States until the late 1980s. Peeled shrimp products have now grown to nearly 25 percent of Chinese exports to the United States (appendices F and G). Until 1989, India had been the largest peeled frozen shrimp supplier to the U.S. market. Low labor costs have enabled the Chinese to increase the added value component of its exports and thus make shrimp exports to the United States even more profitable.

3. Europe

Chinese shrimp exporters have only recently entered the European market. Previously, sporadic

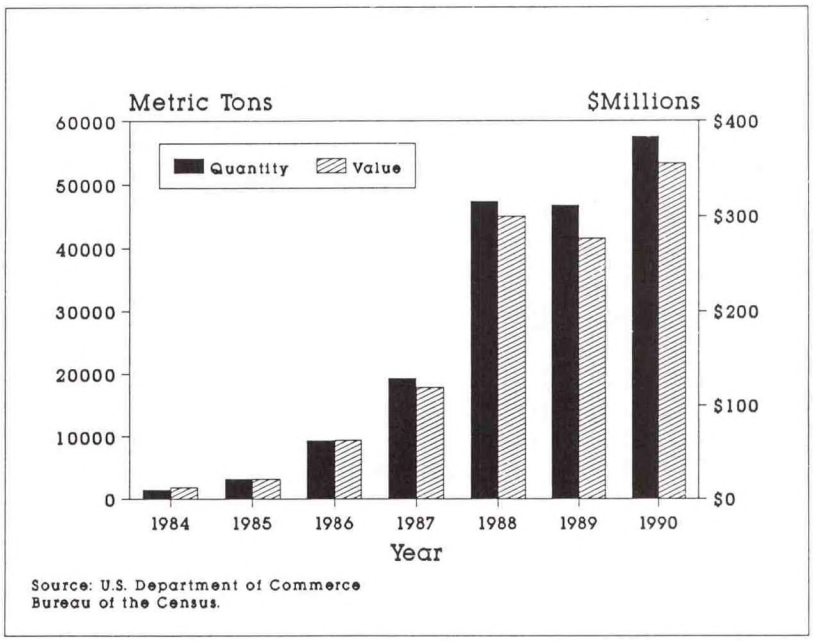

Figure 6. United States. Imports of Chinese shrimp, by quantity and value, 1984-90.

buying used to take place via Hong Kong when European buyers were not accustomed to direct trading with China. China's trade liberalization policy, however, has helped change this trend.

China currently exports shrimp to the United Kingdom, Spain, Italy, Belgium, and Germany. Most of these exports are channeled through Hong Kong. Direct purchases from farms are decreasing as trading companies now take care of bulk orders. Such trading companies also help to insure the quality of the product. Spain and Belgium take mostly head-on product, while Germany, Italy, and the United Kingdom take head-off and peeled product. The most dramatic increase has been reported by the United Kingdom where exports increased 25 percent during the 1986-1988 period. Here as well, demand for value-added peeled shrimp products has been especially strong.

VIII. OUTLOOK

There is great potential for continued shrimp culture development in China. Only about a quarter of the 8 million ha of water area available for aquaculture in China is currently under cultivation. The industry is still centered in the north, where yields are relatively low. Only limited development of the significant potential of southern China has yet occurred. Despite the remarkable growth in China's shrimp aquaculture industry, many problems face the country as it attempts to expand shrimp harvests. The most pressing problems include:

1. Pollution: sewage from cities and agricultural chemicals contribute to the red tides and disease epidemics that strike shrimp farms.

2. Infrastructure: lack of basic infrastructure necessary for shrimp production (e.g., electricity, roads, aquaculture equipment) fundamentally hinders China's ability to increase cultured shrimp production.

3. Seedstock: seedstock supplies are still highly seasonal. Although hatcheries have alleviated the pl problem, hatchery methods need improvement. With the use of wild spawners to be discontinued in 1990, further expansion of the industry will depend on improved hatchery operations.

4. Feed: The high cost of feed is a critical problem for the industry. Since feed is the leading cost on most farms, development of a better formulated and cost-effective feed is necessary.

All of the above problems have led some industry observers to doubt the realism of China's future production goals. These observers argue that until these problems are alleviated, China will not be able to achieve major harvest increases.

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APPENDICES

Appendix A. World. Shrimp Aquaculture production; by country, 1980, 1985-1990.

Country	Year						
	1980	1985	1986	1987	1988	1989	1990
	1,000 Metric Tons						
China	2.0	35.0	70.0	150.0	200.0	165.0	150.0*
Taiwan	5.0	33.3	65.0	75.0	35.0	20.0*	30.0
Indonesia	35.0	50.0	53.0	73.0	96.0	90.0	120.0*
Ecuador	9.2	27.0	36.2	38.0	70.0	45.0	73.0
Thailand	10.0	15.8	17.9	30.0	45.0	90.0	110.0*
Bangladesh	7.0	12.5	13.5	14.5	15.0	-	25.0
India	12.0	17.0	18.0	22.0	24.0	25.0	32.0
Philippines	1.5	28.5	30.5	35.1	36.4	50.0	30.0
Vietnam	4.0	7.0	7.0	7.0	25.0	30.0*	30.0
Japan	1.6	1.9	2.0	7.0	7.0	-	3.5
Peru	1.0	2.1	3.7	4.0	4.0	-	-
Panama	0.4	1.5	1.8	1.9	2.0	-	-
Others	7.8	16.2	18.8	21.0	25.0	49.8	29.4
Total	96.5	247.8	337.4	478.5	584.4	564.8	632.9

*-estimated
Sources: 1980-1988; Globefish, 11/6/89.
1989; World Shrimp Farming 1989, January 1990.
1990; World Shrimp Farming 1990, December 1990.

Appendix B.--China. Hectares of shrimp ponds under cultivation; by province, 1982-1988.

Province	Year						
	1982	1983	1984	1985	1986	1987	1988
	--Hectares--						
Shangdong	8,300	7,800	11,200	17,200	23,400	35,000	81,640
Liaoning	1,900	3,600	8,500	17,100	21,300	27,700	46,710
Hebei	1,000	1,800	3,100	5,900	9,700	14,000	26,560
Jiangsu	2,900	3,700	4,900	8,400	8,700	10,900	17,780
Fujian	900	700	1,200	2,900	7,000	14,200	22,180
Guangdong	700	200	2,200	2,000	5,100	16,100	24,140
Zhejiang	300	900	1,200	2,700	5,400	7,100	11,570
Tianjin	100	500	300	2,200	2,800	3,500	6,210
Shanghai	100	200	400	400	900	1,300	2,420
Guangxi	300	400	400	400	700	1,200	2,770
Total	16,500	19,800	33,400	59,500	85,008	131,000	241,980

Sources: 1982-1987: The Culture of Cold Water Shrimp:Proceedings of an Asian-U.S. workshop on Shrimp Culture, pages 156-157. 1988: Bureau of Aquatic Products, Ministry of Agriculture, Beijing, China.

Appendix C.--China. Cultured shrimp production; by province and quantity, 1982-1988.

Province	Year						
	1982	1983	1984	1985	1986	1987	1988
	--Metric tons--						
Liaoning	700	1,800	6,000	11,900	24,499	43,500	40,721
Shangdong	2,100	3,200	5,300	9,100	17,400	33,900	56,214
Hebei	40	200	1,000	5,200	12,000	24,900	36,975
Jiangsu	2,100	2,300	3,500	5,900	8,400	11,800	13,345
Fujian	200	300	400	1,700	6,200	13,300	20,588
Zhejiang	200	500	1,200	750	5,800	7,200	5,578
Guangdong	1,500	200	900	2,800	4,400	11,600	15,144
Tianjin	90	200	500	1,100	2,400	4,400	6,369
Shanghai	50	200	500	2,100	1,400	2,000	3,093
Guangxi	50	500	30	60	80	300	670
Total	7,030	9,400	19,330	40,610	82,780	152,900	198,697

Sources: 1982-1987; The Culture of Cold-Tolerant Shrimp: Proceedings of an Asian-U.S. workshop on Shrimp Culture, pages 156-157. 1988: Bureau of Aquatic Products, Ministry of Agriculture, Beijing, China.

Appendix D.--China. Total shrimp exports; by country and quantity, 1984-1989.

Country	Year					
	1984	1985	1986	1987	1988	1989
	--Metric tons--					
United States	1,468	3,142	9,373	19,241	47,317	46,717
Japan	10,307	10,664	18,723	27,898	38,122	37,568
Other	5,325	5,594	12,904	12,961	12,761	N/A
Total	17,100	19,400	41,000	60,100	98,200	N/A

N/A - Not available.
Sources: Japanese Imports of Marine Products, Japan Marine Products Importers Association, 1980-1988; Japan's Exports and Imports: Commodity by Country, Vol. 89/12 (1989 statistics); U.S. Department of Commerce, Bureau of the Census.

Appendix E.--China. Exports of fresh and frozen shrimp to Japan; by quantity, value, and average annual price, 1980-1990.

Year	Quantity	Value	Average Price
	--Metric tons--	--$1,000--	--$/kg--
1980	14,501	136,760	9.43
1981	14,954	137,277	9.18
1982	7,253	81,313	11.21
1983	5,778	60,800	10.52
1984	10,307	81,788	7.93
1985	10,664	83,044	7.79
1986	18,723	173,322	9.26
1987	27,898	253,747	9.10
1988	38,122	318,552	8.36
1989	37,568	271,731	7.23
1990	43,571	328,112	7.53

Sources: Japanese Imports of Marine Products, Japan Marine Products Importers Association, 1980-1988, 1990; Japan's Exports and Imports: Commodity by Country, Vol. 89/12 (1989 statistics).

Appendix F.--China. Shrimp exports to the United States; by commodity and quantity, 1984-1990.

Commodity	Year						
	1984	1985	1986	1987	1988	1989	1990
	--Metric tons--						
Shell-On,							
F/F*	997	2,629	6,401	10,561	36,740	-	-
Frozen♥	-	-	-	-	-	34,287	40,932
Fresh♥	-	-	-	-	-	175	37
Peeled,							
Raw, F/F*	334	422	2,798	7,158	7,759	-	-
Other, F/F*	115	80	167	1,211	2,720	-	-
Frozen♥	-	-	-	-	-	11,794	16,202
Fresh♥	-	-	-	-	-	24	134
Canned	14	11	7	310	98	-	-
Breaded	8	-	-	1	-	1	-
Other Preparations♥	-	-	-	-	-	436	134
Total	1,468	3,142	9,373	19,241	47,317	46,717	57,439

* - F/F = Fresh/Frozen.
♥ - New commodity category starting from 1989. Commodity codes and descriptions changed when the United States switched from the Tariff Schedules of the United States Annotated (TSUSA) to the Harmonized Tariff Schedule (HTS) in 1989.
Source: U.S. Department of Commerce, Bureau of the Census.

Appendix G.--China. Shrimp exports to the United States; by commodity and value, 1984-1990.

Commodity	Year						
	1984	1985	1986	1987	1988	1989	1990
	--$1,000--						
Shell On,							
F/F♦	9,669	17,905	48,183	73,383	241,235	-	-
Frozen♥	-	-	-	-	-	212,671	268,846
Fresh♥	-	-	-	-	-	1,453	201
Peeled,							
Raw, F/F♦	2,191	2,740	13,370	37,718	40,444	-	-
Other, F/F♦	440	591	973	6,630	17,681	-	-
Frozen♥	-	-	-	-	-	59,528	84,515
Fresh♥	-	-	-	-	-	70	505
Canned	21	55	8	1,183	682	-	-
Breaded	67	-	-	-	-	3	-
Other Preparations♥	-	-	-	-	-	2,987	1,039
Total	12,388	21,291	62,534	118,914	300,042	276,712	355,106

♦ - F/F = Fresh/Frozen.
♥ - New commodity category from 1989.
Source: U.S. Department of Commerce, Bureau of the Census.

3.2

INDIA

India has been an important exporter of shrimp for over two centuries, first exporting to neighboring Asian countries, and more recently to the United States and other Western nations. With an average annual harvest of about 194,000 metric tons (t) during the 1980s, India's only real competition for the leading position in shrimp production during this period was China. Since 1984, however, because of the widespread use of advanced aquacultural techniques in China, India has found itself permanently relegated to second place, with Indonesia beginning to pose a serious challenge in terms of production and export potential. The central weakness of the Indian shrimp industry is that harvests have remained almost stagnant during the last decade. If India can successfully implement its national program for cultured shrimp development, however, there is a strong possibility that it could reemerge as the world's top exporter. The Government's optimistic projections provide for tripling current (1988) exports of 56,000 t to 150,000 tons by 1995.

CONTENTS

I. BACKGROUND

The state of Kerala, which covers the southwestern tip of the Indian sub-continent (figure 1) is the primary producer of Indian shrimp. Kerala fishermen have been exporting dried shrimp to Sri Lanka, Burma, Singapore, and Malaysia for the last two centuries. Records at the Cochin Chamber of Commerce show that in 1939 that city alone exported 6,000 metric tons (t) of dried shrimp to neighboring countries, or 15 percent of the total shrimp production of 40,000 tons.

The first attempt to export frozen shrimp was made in 1950 by the "Cochin Company" owned by Mr. Madhavan Nair. Assisted by F.S. Kerr, a U.S. citizen working in India, Nair set up the country's first freezing plant. The initial success of the project was followed by a visit to Japan by Nair in 1952 to study the Japanese methods of processing and procedures for importing shrimp. Armed with the technical knowledge provided by Japan's Taiyo Gyogyo Company, Nair returned to India and subsequently made the first frozen shrimp shipment (1 ton) to the United States in August 1952. Followed by the success of the Cochin Company, a number of entrepreneurs in the Cochin area also started

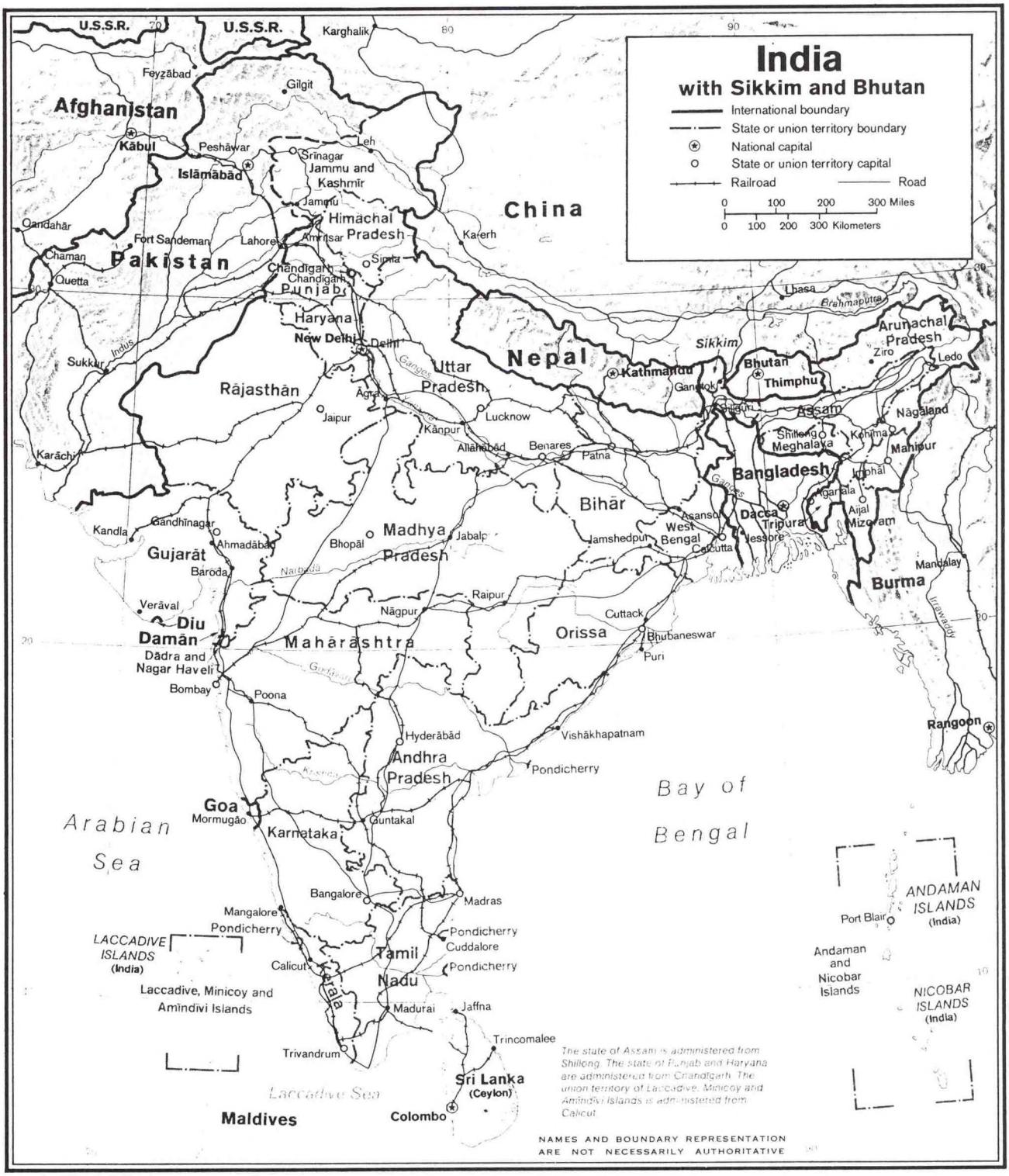


***Figure 1.**--Map of India.*

processing and exporting frozen shrimp to the United States. In fact, for the years 1952-57, nearly all exports of frozen shrimp from India were directed at the U.S. market. In 1957, however, several canning factories were constructed and the export of large quantities of canned shrimp to the United Kingdom was begun.

Until 1955, the shrimp industry in India was chiefly confined to the state of Kerala. During the late 1950s, however, shrimp culture and processing operations began to emerge in Mangalore, Bombay, and Veravel along the western coast of India. It was not until the early 1970s, however, that processing plants along the eastern coast of India in locations such as Madras, Vizhapatnam, Kadalur, Bhubaneshwari and Calcutta began to emerge.

II. PRODUCTION

Shrimp production in India during the last decade has averaged about 128,000 t of *Penaeid* and 65,000 t of non-*Penaeid* shrimp annually (appendix A). India and China alternated as the leading producer of shrimp through the late 1970s and early 1980s. India topped the list of world producers in 1980, 1982, and 1983, while China took the lead in 1981 and from 1984 onwards. Presently, Indian shrimp production averages around 215,000 t per year, though in 1988 the level of production reached over 236,000 tons. The Indian contribution to the total world shrimp production is around 10 percent (appendix B).

The 1988 production of shrimp from the combined sources of marine waters, inland waters and aquaculture totaled 237,000 tons. Shrimp constitutes approximately 10 to 15 percent of the total annual marine catch in India. The marine shrimp resources in India are mainly confined to inshore waters within a depth of 50 meters. The estimate of potential marine shrimp resources is about 285,000 t annually, comprised of 180,000 t of Penaeid and 105,000 t of non-Penaeid species.

That India is one of the major world producers of shrimp is virtually unknown to the consuming public of the advanced countries where its shrimp is processed and consumed. India can match the present Chinese level of production if it develops modern aquaculture on a priority basis. If India cannot revolutionize its shrimp industry through the use of intensive breeding techniques, however, it is quite possible that Indonesia and Thailand will soon surpass India in shrimp production.

III. SPECIES COMPOSITION

A great variety of shrimp abound in the offshore and inland waters of India. Nearly 52 species contribute to the fishery, and of these, about eight species of *Penaeid* and six species of non-*Penaeid* shrimp are of considerable significance. Details of the shrimp catch classified by species are available only through the period 1981-85. An analysis of this data shows that the production of Indian white shrimp (*Penaeus indicus*) varied between 7,000 to 9,000 t during the early 1980s. After 1985, it increased to 15,000 tons. The other major species of flower shrimp (*Semi-selecatus*) has been fairly constant, varying from 7,000 to 9,000 t per year.

The catch of brown shrimp (*Metapenaeus Dobsoni, Parapenaeus Stylifera*), which is the dominant species in Indian waters, varied between 80,000-90,000 t during the first half of the 1980s, and fluctuated between 110,000 to 130,000 t after 1985. It is the tiger shrimp (*Penaeus monodon*) however, which has shown the most dramatic increase in the second half of the 1980s. Whereas the production of tiger shrimp averaged around 1,000 to 1,500 t up until 1984, it spurted to over 10,000 t in 1985. With India now making serious attempts at scientific aquaculture, the share of tiger shrimp in total shrimp production will likely become more prominent in the coming years.

IV. HARVESTS

Inshore Capture: Shrimp harvest from inshore waters averages around 200,000 t per year. The number of vessels engaged in fishing for shrimp in the inshore waters has increased considerably during the last decade, and consequently the catch per unit of effort has come down drastically. Recent investigations have shown that the inshore waters have been almost fully exploited, and there is apparently not much room for additional small mechanized craft in the inshore waters less than 50 meters deep.

To prevent over-exploitation of the coastal waters, the various state governments are contemplating measures to avoid the indiscriminate catching of fish and shrimp fry to allow them to grow to a more suitable size. A three-month closure of the coastal fishing grounds was enacted for all maritime states of India in 1989. Regulation of fishing in Indian waters is presently vested in the individual State governments. Attempts to evolve a national policy to regulate fishing for purposes of resource management and conservation are in progress.

Deepsea Fishing: The exploitable shrimp resources in the Indian waters 50 m deep or more are estimated at 20,000 tons. Trawlers 20 m long or longer, are needed to successfully exploit these resources. The present government policy encourages deepsea fishing through joint ventures and the chartering of foreign fishing vessels. This should marginally augment shrimp production from the deepsea waters in the Indian exclusive economic zone (EEZ).

At present, the catch from deepsea trawlers accounts for only 15 percent of total Indian shrimp exports. There are 171 deepsea trawlers fishing in waters between the 50 m and 200 m depth zone. Of this Indian deepsea fleet, 168 vessels are shrimpers, two are tuna boats (one long-line and one pole and line), and one is a stern trawler that is used for miscellaneous fishing. The Government of India has devised a plan to increase the deepsea fleet to 500 vessels by the end of 1989. However, this expansion will center on joint ventures in deepsea fishing for exploitable fishery resources other than shrimp since the government feels that there should not be any further emphasis on shrimpers.

As a result of concern over marine shrimp resources, the government has also become more selective in authorizing the acquisition of fishing vessels. By choosing vessels fitted with out-riggers and other shrimping devices, the priority has been placed on vessels designed for catching non-shrimp resources such as tuna, cuttlefish, and squid. Consequently, the level of shrimp catch from deepsea fishing is expected to increase only marginally in coming years.

Aquaculture: Aquaculture seems to be the only way for India to immediately increase its shrimp production and maintain its position as one of the leading shrimp producing and exporting countries of the world. Shrimp production from inshore capture is stagnant, and in fact shows a declining trend. Deepsea catch of shrimp is capital-intensive and is not likely to show any substantial increase in production in the near future.

India is one of the few countries in the world with rich natural resources suitable for shrimp aquaculture. India has a 7,500 kilometer (km) coastline, and the brackish-water available for aquaculture in the country is now estimated at 1.4 million hectares (ha). Of this total, only 58,000 ha are now being used in traditional methods of rice paddy/shrimp farming employing extensive methods of culture (appendix C).

The present average yield from the traditional paddy/shrimp culture is around 300 kilograms (kg) per ha over a period of 5 months. Traditional paddy/shrimp farming is carried out in West Bengal, Kerala, Karnataka and Goa. One crop of rice during the rainy season and one crop of shrimp during the summer are raised in the same area. Under this system, after the harvest of the rice, the fish and shrimp fry are trapped with the incoming tides in fields adjacent to the brackish-water areas. The shrimp are then harvested at fortnightly intervals. There is no fry stocking carried out in such a system, nor are any artificial feeds used. All water management occurs through tidal exchange. The shrimp are not allowed to grow to large size and consequently the production under this system is very low -- ranging from 200 to 500 kg per ha of small, low-value shrimp.

There are a handful of farmers now employing semi-intensive methods of shrimp culture, obtaining 1,200 kg per ha per crop in the 4 to 5 month culture period. These farmers introduce shrimp fry into their ponds, but no scientific feed is used and no water management is employed except for natural tidal exchange. At present, the only modern scientific shrimp farm in India is that of Hindustan Lever Ltd., which was set up in West Bengal. Hindustan Lever has been able to obtain 7,500 kg per ha per crop. A large number of private companies are now in the process of setting up scientifically planned shrimp farms using both semi-intensive and intensive methods of culture. About 5,000 ha of such modern farms are expected to begin production by 1991. A large number of joint ventures have also recently been formed between the Indian private sector and some of the world's major shrimp farmers. The joint ventures aim at setting up scientifically managed shrimp farms.

Scientifically produced aquaculture feed is still not available in India and must be imported. However,

some of the major world producers of aquaculture feed are now in the process of constructing plants in India for the manufacture of such feed.

V. PROCESSING FACILITIES

Capacity: Indian shrimp is usually processed in conventional block frozen form in either 2 kg or 5 lb packs. Canned shrimp, at present, is virtually non-existent. India continues to be a supplier of shrimp for reprocessing in the consuming countries such as the U.S. and Japan. In the last two years, due to a variety of incentives provided by the Government of India, a large number of modern individual quick-freezing units have been set up to facilitate the processing of raw and cooked frozen shrimp. There is one unit very successfully producing freeze-dried shrimp in technical and financial collaboration with Nissin Food Products Company of Japan. A few major Japanese companies like Itoman & Company, Ltd., are currently setting up units for processing value-added shrimp products in India (appendix E).

Methods: The industry has built up its processing and production capacity over the years in anticipation of increased availability of raw material. The stagnation in raw material supply, however, has resulted in under-utilization of built-up capacity which could be employed to handle increased production anticipated from large-scale shrimp aquaculture and more intensive deepsea fishing efforts.

Steps are being taken to update or replace obsolete freezing equipment with modern factories and to install more instant quick-freeze (IQF) plants. The total quantity of value-added shrimp products is expected to increase substantially in the coming years, gradually replacing present exports of block-frozen raw material.

VI. MARKETS

Domestic: Annual per capita consumption of fish and fish products in India was only 3.1 kg during the 1982-84 period and this level has not changed substantially since that time. *Penaeid* shrimp forms an insignificant fraction in domestic consumption, while the non-*Penaeid* shrimp catch is almost fully absorbed by the domestic market. A proper distribution system for the marketing of frozen food on a national scale is still non-existent in India. As a result, no increase in domestic consumption of the expensive *Penaeid* shrimp is foreseen for the near future. The traditional fishermen, who tend to sell their own catch, are the only outlets for the selling of shrimp for local consumption. Consequently, the *Penaeid* species will continue to be an exportable commodity until such time as an effective domestic distribution and marketing system becomes available.

Exports: Although there are about 30 fishery products exported from India, shrimp is by far the principal item, accounting for 60 percent in volume and 80 percent in value of all marine product exports. Indian exports of shrimp during the last decade have varied only marginally in terms of volume. The export flow has fluctuated from 47,000 to 55,000 t, but the value has shown a consistent increase from U.S.$140 million in 1980 to U.S.$330 million in 1988 (appendix D).

Between the early 1950s and 1970s, the United States was India's main market for frozen shrimp. Since the early 1970s, however, Japan has clearly been the primary market for Indian shrimp, accounting for nearly 65% in volume and 75% in value of total Indian shrimp exports. From the mid-1970s, however, Japan's share of India's shrimp export market has slowly declined, with export volume dropping from 36,408 t in 1980 to only 31,000 t in 1988. Japan imports both bigger shell-on and smaller peeled varieties, while the United States, the second-largest importer, imports smaller peeled and de-veined varieties of Indian shrimp.

The United States accounts for about 20% in volume and over 13% in value of Indian shrimp exports. However, there has been a steady increase in the exports to the United States from 6,615 t in 1980 to 12,887 t in 1988. The third major market is the United Kingdom, which has also shown a marked increase from 1,336 t in 1980 to 6,868 t in 1988. In the last few years, Spain, France, Belgium and the Netherlands have also emerged as substantial buyers of Indian shrimp, importing between 700 and 800 t each on an annual basis. Overall, the market for Indian shrimp is currently spread over 30 countries around the world.

VII. QUALITY CONTROL

The level of Indian shrimp production is very carefully monitored for quality by a governmental agency specifically created for this purpose. The organization responsible is called the Export Inspection Agency (EIA) and since 1985 all fish are subject to compulsory quality control with pre-shipment inspection.

Any processing plant producing fishery products for export must obtain the prior approval of the EIA before they can commence production. Quality control measures begin immediately after landing under supervision of EIA technical staff. The processing plant must employ qualified technicians approved by the EIA. The final product is subject to detailed physical and bacteriological examination by the EIA prior to shipment. Inspection certificates are issued by the EIA after quality has been assured. No export of marine products is possible without this export certificate, and even with the certificate, marine fishery products awaiting shipment are also subject to re-assessment of quality.

Recently, the EIA has been permitting certain select factories which have the required testing facilities and qualified technical staff, to conduct their own inspections. Such processors are authorized to certify the quality of their products for export. Permission for such self-certification is given to only a few select firms whose record of trade, manufacturing practices, quality control laboratory and testing systems meet both national and international standards.

The enforcement of the Export Quality Control and Inspection Act has greatly improved the quality standards of marine products processed for export. Although in the initial years, the system of quality control may not have been totally effective, it is now working satisfactorily. The instances of poor-quality claims against exports of Indian marine products are now few and far between. Further, any quality control claims are thoroughly investigated by the EIA and the exporter is liable to have his processing license canceled and factory shut down if his products fail to meet the quality standards set by the EIA.

VIII. ROLE OF THE MPEDA

The Marine Products Export Development Authority (MPEDA) was established by the Government of India under an act of Parliament in September 1972. The statute made the MPEDA responsible for the overall development of the Indian seafood industry with special emphasis on export production and promotion.

The MPEDA has both regulatory and promotional functions. The organization is headed by a senior civil servant of the Government of India who assumes the position of MPEDA Chairman. Since its creation, the MPEDA has greatly contributed to the growth and modernization of the Indian seafood industry. It would be difficult to list all of the promotional schemes and programs supported by the MPEDA. However, some of the programs worth mention are:

1) Financial assistance and regulatory measures to modernize fishing harbors, coastal landing centers and peeling stations, so that the marine catch is landed and pre-processed under hygienic conditions.

2) Financial and technical assistance to the private sector to acquire modern refrigerated trucks and also to upgrade existing plant and equipment.

3) Financial assistance for deepsea fishing, detailed surveys on prospective aquaculture areas, and the construction of two large, modern commercial hatcheries.

4) Direct technical assistance to indigenous Indian shrimp farmers.

5) Collection and dissemination of data and statistics on all aspects of the Indian fishing industry by the MPEDA in India, as well as by the branch offices in New York and Tokyo.

6) Regulation of marine production: providing assistance for training personnel employed in the marine products industry and conducting various market studies in major international markets for the export of Indian seafood.

IX. OUTLOOK

As stated earlier, India has a long tradition of processing and exporting marine products both to neighboring Asian countries and to nations of the West such as the U.S. and U.K. India has a well organized if somewhat labor-intensive system of handling the shrimp through the process of landing, peeling, and processing for export.

There are over 500,000 skilled personnel engaged exclusively in the peeling and processing of shrimp in various processing centers in India. Such a singularly skilled work force is probably not available anywhere else in the world. This major strength of the Indian shrimp industry enables hand-peeling of the tiniest of fresh shrimp with minimum waste at a very economical cost. This has enabled India to provide small-sized peeled shrimp at competitive world prices. The handling of shrimp from the time of catch to the processing phase has greatly improved in the last three years, but there is still room for further modernization.

The Government of India has realized that there is vast potential for earning foreign exchange through the export of seafood. Consequently, a national policy has been formulated to encourage rapid development of the marine product industry, and to ensure that India retains its status as one of the leading world shrimp producers. As a result of this policy, the deepsea fishing fleet has been expanded, a crash program for rapid development of aquaculture is under implementation, and financial assistance is being provided to processing plants to modernize and update their equipment and technology. Through the MPEDA, the Government is also encouraging domestic processors to export more of value-added products rather than just raw materials.

A primary problem for the Indian shrimp industry is the fact that supply has remained almost stagnant during the last decade. The only solution for this problem is to increase production levels through the use of modern scientific methods of shrimp culture. For example, by converting the traditional prawn filtration farms (which now yield an average of 300 kgs per ha per annum) to semi-intensive farms (capable of producing 1,500 kgs per ha per annum), total production can be increased dramatically from the present level of 20,000 t to 100,000 t per annum. This level of production is estimated from the 58,000 ha presently utilized under traditional farming methods. This dramatic turn-around in shrimp production can be achieved very quickly by providing traditional farmers with low-cost prawn fry, nutritionally balanced shrimp feed, and technical assistance with regard to stocking, feeding, and water management.

If India can successfully implement its national program for shrimp development, it will likely re-emerge as the world's top exporter. The present level of exports could be dramatically increased to 150,000 tons or more by 1995. This ambitious program is entirely dependent on the development of aquaculture in the next two years.

This report was originally prepared by Todd Schneider and published as IFR-91/18 on March 14, 1991.

SOURCE

Tharakan, Abraham. **Shrimp Production in India: A Review**, 1990.

APPENDICES

Appendix A -- India. Shrimp production, 1981-89.

Year	Species			Annual % Change +(-)
	Penaeid	Non-Penaeid	Total	
	--Metric tons--			
1981	83,502	61,467	144,969	
1982	110,771	51,175	161,946	12%
1983	118,203	49,387	167,590	3%
1984	130,051	62,628	192,679	15%
1985	161,842	70,245	232,087	20%
1986	137,877	74,241	221,118	-5%
1987	129,717	69,847	199,564	-10%
1988	156,153	80,443	236,596	19%
Average	128,515	64,930	194,570	

Source: Marine Products Export Development Authority (Government of India). Statistics for 1989 are not yet available.

Appendix B -- World. Shrimp production (both cultured and "wild"), by major countries, 1984-88.

Country	Year				
	1984	1985	1986	1987	1988
	-----Metric tons-----				
China	249,482	366,957	426,595	457,463	583,592
India	203,186	232,189	215,324	197,171	236,596
Indonesia	132,944	144,141	157,338	186,909	202,300
U.S.A.	145,004	152,739	183,313	165,012	150,771
Thailand	136,211	126,290	139,472	150,130	150,130
Mexico	76,114	74,599	73,215	83,882	73,200
Ecuador	39,900	36,228	52,794	78,723	80,800
Malaysia	70,136	69,004	72,861	72,861	72,861
Philippines	52,237	62,399	72,141	68,032	79,644
Greenland	41,493	52,370	64,080	64,839	65,060
Grand Total	1,146,707	1,316,916	1,457,133	1,525,022	1,694,954

Source: FISHDAB, FAO Fisheries Department.

Appendix C -- India. Production of cultured shrimp, by state, 1988. 1988 potential and actual area under cultivation, and production levels.

State	Brackish-water Area*	Ponds		Potential Pond Sites
		Area	Harvest	
	-Hectare-	-Hectare-	-Metric tons-	-Hectare-
West Bengal	405,000	33,210	11,623	25,000
Orissa	80,000	3,165	1,582	32,000
Andhra Pradesh	150,000	3,500	2,100	17,000
Tamilnadu	56,000	176	88	15,000
Pondicherry	800	-	-	-
Kerala	242,000	8,185	4,092	17,000
Karnataka	8,000	1,800	720	N.A.
Goa	18,000	6,500	2,600	N.A.
Maharashtra	80,000	1,800	720	14,000
Gujarat	376,000	100	40	2,000
Total	1,416,300	58,376	23,566	122,000

*Estimated
Source: Marine Products Export Development Authority (Government of India).

Appendix D -- India. Export of frozen shrimp, by major countries, 1980-88.

Country	Year					
	1980	1984	1985	1986	1987	1988
	--Metric tons--					
Japan	36,408	38,160	33,500	33,691	32,521	31,000
U.S.A.	6,615	10,982	9,208	10,462	12,027	12,887
U.K.	1,339	4,382	4,231	4,383	3,929	6,868
France	424	140	562	751	935	839
Spain	82	0	122	580	389	788
Belgium	147	552	514	662	563	748
Nether-lands	1,818	4,383	262	481	315	741
Malaysia	11	65	273	188	352	563
U.A.E.	35	267	398	438	288	521
Singapore	12	12	42	146	26	211
Australia	414	139	182	147	189	157
Germany	11	34	32	34	11	28
Others*	446	309	218	190	84	622
Total	47,762	55,194	49,544	52,153	51,629	55,973

* Includes Algeria, Mauritius, Canada, Mexico, Sri Lanka, Hong Kong, Thailand, Bahrain, Kuwait, Qatar, Saudi Arabia, Oman, USSR, Portugal, Switzerland, and Greece.
Source: Government of India. Marine Products Export Development Authority.

Appendix E -- India. Processing plants and other infrastructure related to marine fishery exports, January 1, 1990.

Type	Plants	Daily Capacity
	-Number-	-Metric tons-
Freezing Plants	273	2,094
Other Cold Stores	300	41,838
IQF	24	110
Canneries	27	92
Fishmeal Plants	29	435
Dried Fish Stores	426	26,363
Pre-processing Units	953	3,255
Insulated/Refrigerated Vehicles	483	-

Source: Government of India. Marine Products Export Development Authority.

3.3

INDONESIA

Indonesian fishery exports have increased rapidly during recent years. Among fishery products, cultured shrimp exports have expanded most dramatically, primarily in response to Japanese market demand. As a result, Indonesia has become the second most important producer of cultured shrimp in the world, behind China. Production reached an estimated 70,000 metric tons (t) in 1988, compared to 52,000 t in 1987. This growth reflects substantial new domestic and foreign investment in shrimp farms. The future growth of Indonesia's export-oriented shrimp culture industry, as well as that of other Asian countries, may be substantially affected by recent price movements in the Japanese market. Decreased consumption and over-stocking during 1988-89 led to a glut in the Japanese shrimp market, substantially lowering the market price, and profits, for Southeast Asian shrimp producers. Despite unfavorable markets, Indonesian shrimp exports continued to expand in 1988 and were a significant foreign exchange earner.

CONTENTS

I. HARVESTS

As the world's largest archipelago, Indonesia is uniquely situated to benefit from the development of both freshwater and brackish-water fish and shrimp aquaculture (figure 1). The fisheries sector has traditionally been an important source of income and employment, and the shrimp trawl industry was the first major commercial fishery to develop in Indonesia. In order to prevent over-exploitation of marine shrimp, however, and to protect the livelihood of traditional fishermen, the Government imposed a ban on trawling along the coast of Java in 1980 and Sumatra in 1981. The ban was extended to cover the entire country in 1983, and then lifted for the eastern part in 1985. As a result, marine shrimp catches declined during those years. Marine landings of shrimp averaged only 104,000 t during 1982-84, down from 133,000 t in 1981.

Despite the trawling ban, shrimp production as a whole has shown steady expansion. Brackish-water cultured shrimp production has increased most of all sectors of the shrimp industry. Indonesia's cultured shrimp harvests have grown from 32,000 t in 1984 to 52,000 t in 1987 (appendix A), an increase of more than 60 percent. This earned Indonesia the distinction of being the world's fourth largest cultured shrimp producer behind Taiwan, Ecuador, and China. Preliminary 1988

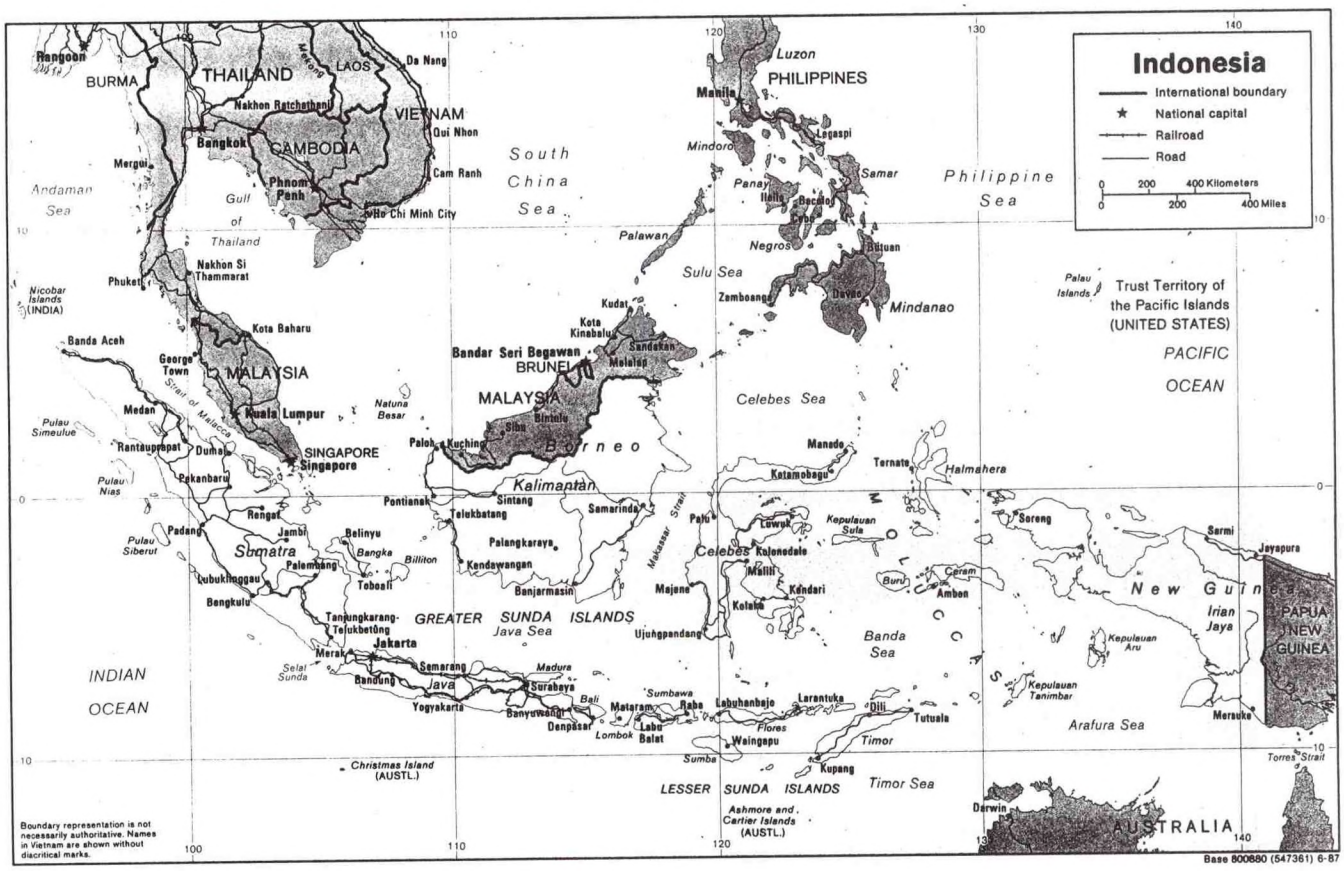


***Figure 1.**--Map of Indonesia.*

statistics indicate that Indonesia may have increased its production to 70,000 t, making it second only to China.

II. CULTURE TECHNIQUES

Brackish-water aquaculture in Indonesia is a centuries-long tradition. It developed from a mangrove swamp fishery using traps constructed as simple tidal ponds. The majority of the tidal culture ponds ("tambaks") are now located along the northern coast of Java, southern Sulawesi (Celebes), and the province of Aceh in Sumatra.

Traditional methods of milkfish and shrimp culture are still in use by an estimated 80 percent of Indonesian pond managers. Ponds are stocked with fish and shrimp swept into them with the incoming tide and then caught by "straining" the pond water as the tide ebbs. There is little control over water depths and salinity levels and no additional stocking or feeding is done. While some pond managers may harvest on a daily basis, ponds are normally drained and harvested twice a year. Yields are low, ranging from 500-700 kg per hectare (ha) annually of mixed species. Shrimp is usually only a small portion of the harvest.

The increase in world demand for shrimp and the effects of the marine trawling ban on shrimp supply caused the prices offered for cultured shrimp to rise sharply. This development induced tambak operators to begin concentrating on commercial production of shrimp rather than milkfish in the early 1980s. Pond managers also began to adopt semi-intensive culture practices, including improved control of salinity and water depths, and increased stocking and feeding. Thus, shrimp yields have increased sharply in recent years.

Indonesia's shrimp culture industry has undergone additional changes since the early 1980s. There has been a large increase in the commercial development of intensive-culture tambaks, using

Photo 1.--Indonesia. Shrimp tambaks. ©Michael New-AADCP

predominantly Taiwanese technology. There has been considerable improvement in pond construction methods. The tambaks are being constructed specifically for the production of giant tiger shrimp. Pumps and paddle wheels are being used to facilitate water exchange and improve aeration of the ponds. Pond managers have also increased stocking rates and are using formulated feeds. The new intensive ponds can yield 4-7 t per ha per crop with some managers reporting 2 or more harvests per year.

Managers are also upgrading their traditional ponds for semi-intensive operations. Average shrimp yields from tambaks increased by 67 percent from 1983 to 1984, and the total production of cultured shrimp has more than doubled since 1980. Indonesia's Ministry of Agriculture estimates that brackish-water shrimp ponds covered approximately 250,000 ha in 1987, with a potential of 3 million ha suitable for pond development.

III. INVESTMENT

Shrimp culture has attracted the interest of a wide range of businessmen in Indonesia. Most of the new intensive and semi-intensive ponds, developed in 1988-90, have been the result of corporate investment rather than investment by traditional tambak owners. According to Indonesia's Capital Investment Coordinating Board (BKPM), domestic investments in the fisheries sector quadrupled from 1985 to 1988 (appendix B). Foreign investment in the fishing industry has increased at an even more rapid pace: from $12 million in 1987 to approximately $170 million in 1988, a fourteen-fold increase.

To protect the small traditional producers, the Government has limited commercial producers to 30 ha of company-owned ponds. This limit can be extended under a "nucleus estate system." In practice, many companies in the industry are becoming increasingly "vertically integrated," operating their own hatcheries, ponds, processing plants, and cold storage facilities. Processing companies are also increasingly offering extension services to the pond owners, supplying them with shrimp larvae, for example.

IV. SHRIMP FEED

Shrimp feed imports increased from 190 t in 1984 to 9,500 t in 1987 and a staggering 23,700 t during the first 8 months of 1988.[1] This shrimp-feed increase is another manifestation of the growth of shrimp aquaculture. Taiwan is currently the largest supplier of shrimp feed to Indonesia, although Indonesia's own feed producers have themselves produced small quantities of feed since 1987. Indonesia, however, is a high-cost producer of the major shrimp feed ingredients and does not have a comparative advantage at this time.

V. HATCHERIES

Indonesia is fortunate to have relatively abundant stocks of wild shrimp fry, but there are still periodic shortages of high-quality fry. Through the mid-1980s, the availability of sufficient quantities

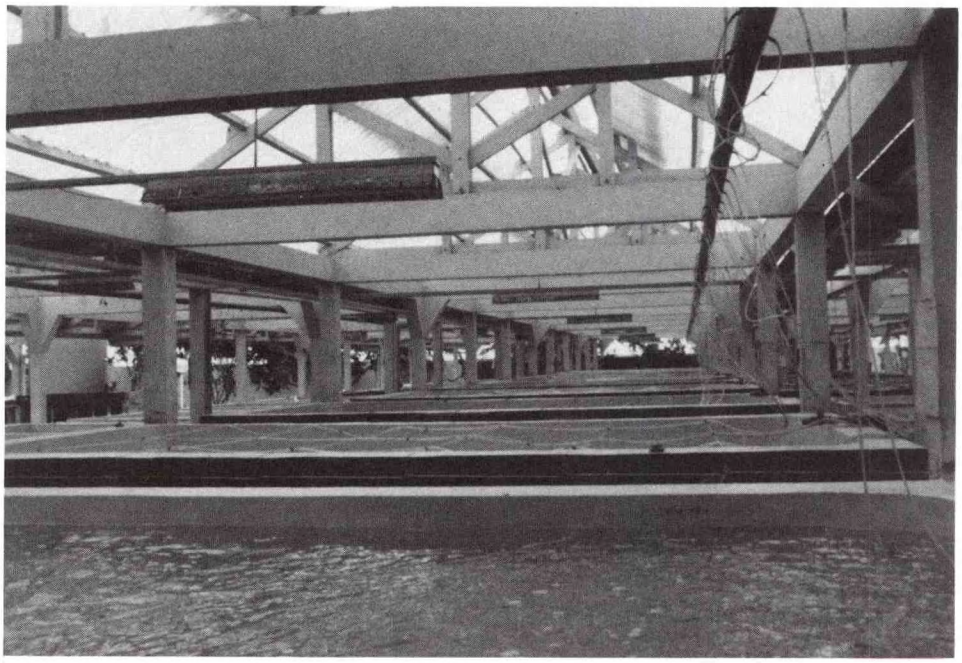


Photo 2. --Indonesia. Indonesian hatchery. © Henry R. Branstetter.

of shrimp fry was a significant constraint on the industry's expansion (photo 1). As a result, many hatchery projects were initiated. Nearly 100 hatcheries were operating in 1987 and their number continues to grow.

VI. EXPORTS

Indonesian shrimp exports have surged during the last 6 years (appendix C). The 1983 exports of 26,200 t increased to 56,200 t by 1988, or by 114 percent. Their value increased even more, from $194 million in 1983 to $500 million in 1988 (157 percent). Complete data for 1988 are not yet available, but in 1987 shrimp exports accounted for 30 percent (by quantity) of all Indonesian fishery exports and as much as 75 percent of the value of such exports. Industry observers believe that Indonesia may be exporting nearly 73,000 t of shrimp by the end of 1990, of which 40,000-50,000 t would be cultured. The Indonesian Directorate General of Fisheries (DGF) is projecting the value of fishery exports to exceed $1 billion by the end of the current five-year development plan (1993). Of this sum, shrimp is expected to contribute approximately 75 percent ($750 million).

Japan is by far the most important market for Indonesian shrimp exports (appendix D). Indonesian shrimp has enjoyed some advantages in the Japanese market due partly to the consumer's preference for black tiger shrimp, and to joint agreements with Japanese importers who frequently provide financial and/or technical assistance to Indonesian growers. Indonesia accounted for 12.5 percent of the volume and 13.3 percent of the value of total Japanese shrimp imports in 1984. Indonesia further improved its position in 1988 to become the leading supplier of shrimp to the Japanese, accounting for 15 percent by quantity and 16 percent by value of total imports. Shrimp prices in the Japanese market have decreased considerably in 1990 with yet unknown consequences for Indonesian producers.

Exports to neighboring countries and to Europe have also grown, though not quite as dramatically. Until the recent price dip in the Japanese market, Indonesian exporters showed little interest in the U.S. market. Many Indonesian shrimp exporters complained, however, that this has mainly been due to the difficulty of entering the U.S. market. This assertion is at least partly justified in light of the fact that, until 1989, almost all Indonesian shrimp suppliers were on the U.S. Food and Drug Administration's automatic detention list. Indonesian exporters shipped only 1,100 t of shrimp to the United States in 1987, but shipments increased to almost 6,000 t in 1989.

International markets for shrimp have become increasingly cost-competitive and the potential importance of the U.S. market to Indonesian exporters has also increased. This may require the development of a marketing campaign for the black tiger shrimp which, while it has achieved an important market niche, is still not a species generally favored in the United States. American consumers favor peeled and de-veined shrimp while most Indonesian shrimp is currently exported simply as frozen headless. While the peeling and de-veining offer the additional incentive of a value-

added operation, they also increase the possibility of contamination, which is already a serious problem for Indonesian shrimp exporters.

VII. OUTLOOK

The shrimp industry is very attractive because it uses Indonesia's abundant labor and vast tambak areas to generate productive employment, increase the below-average incomes of tambak "farmers," and generate foreign exchange earnings. Current trends indicate increased competition in world shrimp markets with many other countries initiating or expanding shrimp culture operations. This could lead to substantial decreases in prices (in real terms). Even under these conditions, Indonesia has a good potential for further increases in shrimp production and exports. This potential will be realized, however, only if the industry maintains low-cost operations and expands into new markets with high-quality shrimp and a sound knowledge of market demand. Although it is recognized that the present heavy dependence on the Japanese shrimp market is risky, quality levels and export varieties continue to be a problem for Indonesian exporters seeking entry into the U.S. market. The culture of additional shrimp species (i.e., a diversification away from black tiger shrimp production), along with increased attention to product quality, would help Indonesian shrimp exporters to better penetrate both the U.S. and Japanese markets.

To lower farmers' operating costs, imports of shrimp feed and feed ingredients should be unrestricted by tariff and non-tariff trade barriers. Protection of domestic shrimp feed producers will only raise the cost of production of shrimp and damage Indonesia's competitive position in foreign markets.

The shrimp industry, although not a large sector of the Indonesian economy, can continue to contribute significantly to employment, rural incomes, and foreign exchange earnings. Many observers believe that government policies and support for the industry should be aimed at increasing its efficiency and lowering production costs if this potential is to be fully realized.

This report was originally prepared by Todd Schneider and published as IFR-90/40 on May 31, 1990.

SOURCE

U.S. Embassy, Jakarta, July 22, 1989.

ENDNOTE

1. Data supplied by the Indonesian Central Bureau of Statistics.

APPENDICES

Appendix A. -- Indonesia. Shrimp harvest, by type and quantity, 1984-1987.

Year	Type of Production			
	Marine Capture	Freshwater Capture	Brackish-water Culture	Total
	--1,000 Metric tons--			
1984	101	11	32	144
1985	107	13	37	157
1986	117	12	41	170
1987	117	14	52	183

Source: Directorate General of Fisheries, Government of Indonesia.

Appendix B. -- Indonesia. Domestic investments in the fisheries sector, 1985-1988.*

Year	Investments	
	--Rh Millions--	--U.S.$Millions*--
1985	174	9.6
1986	280	15.4
1987	515	28.3
1988**	644	35.4

*(Exchange rate = Rh 1,819 per $1, as of 3/9/90).
**January-November, 1988.
Source: U.S. Embassy, Jakarta, July 22, 1989.

Appendix C. -- Indonesia. Exports of shrimp, by quantity and value, 1983-1988.

Year	Exports	
	Quantity	Value
	--Metric tons--	--$Millions--
1983	26,200	194.4
1984	28,000	195.6
1985	31,000	202.7
1986	36,100	284.9
1987	44,300	352.4
1988	56,600	500.0

Source: Directorate General of Fisheries, Government of Indonesia.

Appendix D. -- Indonesia. Shrimp exports, by country, quantity, and value, 1983 and 1988.

Country	1983		1988	
	Quantity	Value	Quantity	Value
	--1,000 MT--	--$Millions--	--1,000 MT--	--$Millions--
Japan	21.0	170.2	40.4	393.8
Singapore	2.0	6.7	4.9	24.3
Hong Kong	2.2	10.3	2.4	14.2
Belgium*	--	0.2	1.6	12.5
Netherlands	0.3	2.7	1.9	11.7
United States	0.4	2.3	1.7	16.4
Malaysia	0.1	0.6	0.7	1.0
Other	0.2	1.3	3.0	26.1
Total	26.2	194.4	56.6	500.0

MT = Metric Tons.
*Includes Luxembourg.
Source: Directorate General of Fisheries, Government of Indonesia.

3.4

MALAYSIA

Malaysian shrimp aquaculture has begun to succeed commercially after suffering years of heavy financial losses. Improved aquaculture methods and the commitment of a few large companies are largely responsible for the turnaround. Malaysian production, mostly of giant tiger prawns[1] (*Penaeus monodon*) was 1,260 metric tons (t) in 1987, almost five times the 1986 harvest of 270 tons. Estimated 1988 production was 1,800 tons. In 1987, the Malaysians produced 300 million shrimp post larvae (pl) for stocking growout ponds. Production of pl in 1988 was estimated at 360 million. Malaysia's pl production exceeds domestic shrimp farmers' needs, and the surplus is exported--about 78 million pl in 1987 and an estimated 11 million in 1988. About 80 percent of Malaysian shrimp culture production is exported, mostly to Singapore, Japan, the United States, and Europe.

CONTENTS

I. PRODUCTION

Malaysian shrimp farmers harvested 1,260 t of shrimp in 1987, nearly five times the 1986 production (appendix A). Of this total, 760 t were produced in peninsular Malaysia, and 500 tons were produced in Sabah, East Malaysia. The estimated 1988 crop was 1,800 t, with 1,000 t produced in peninsular Malaysia and 800 t produced in Sabah. There are currently about 230 farms operating in Malaysia, covering a total of about 730 hectares (ha). In peninsular Malaysia, 190 farms are operating on 560 ha, and in Sabah, 36 farms cover about 170 hectares. The Malaysian Government has targeted a total of 22,000 ha of mangrove swamp for development into aquaculture ponds, which are expected to yield 21,000 t of shrimp by the year 2000.

Most (about 85 percent) of the cultured shrimp produced in Malaysia are giant tiger prawns (*Penaeus monodon*), with the remaining 15 percent banana prawns (*P. merguiensis*). Both are grown in brackish water ponds.

II. DEVELOPMENT POTENTIAL

Between 1986 and 1988, the Government approved 36 shrimp aquaculture projects with a proposed investment of $122 million. Of this total, 23 projects, worth $102 million were approved in 1988 alone, indicating a dramatic rise in the stock of Malaysian aquaculture. If all 36 projects are completed, their combined production will be about 30,000 t annually, surpassing the Government's official

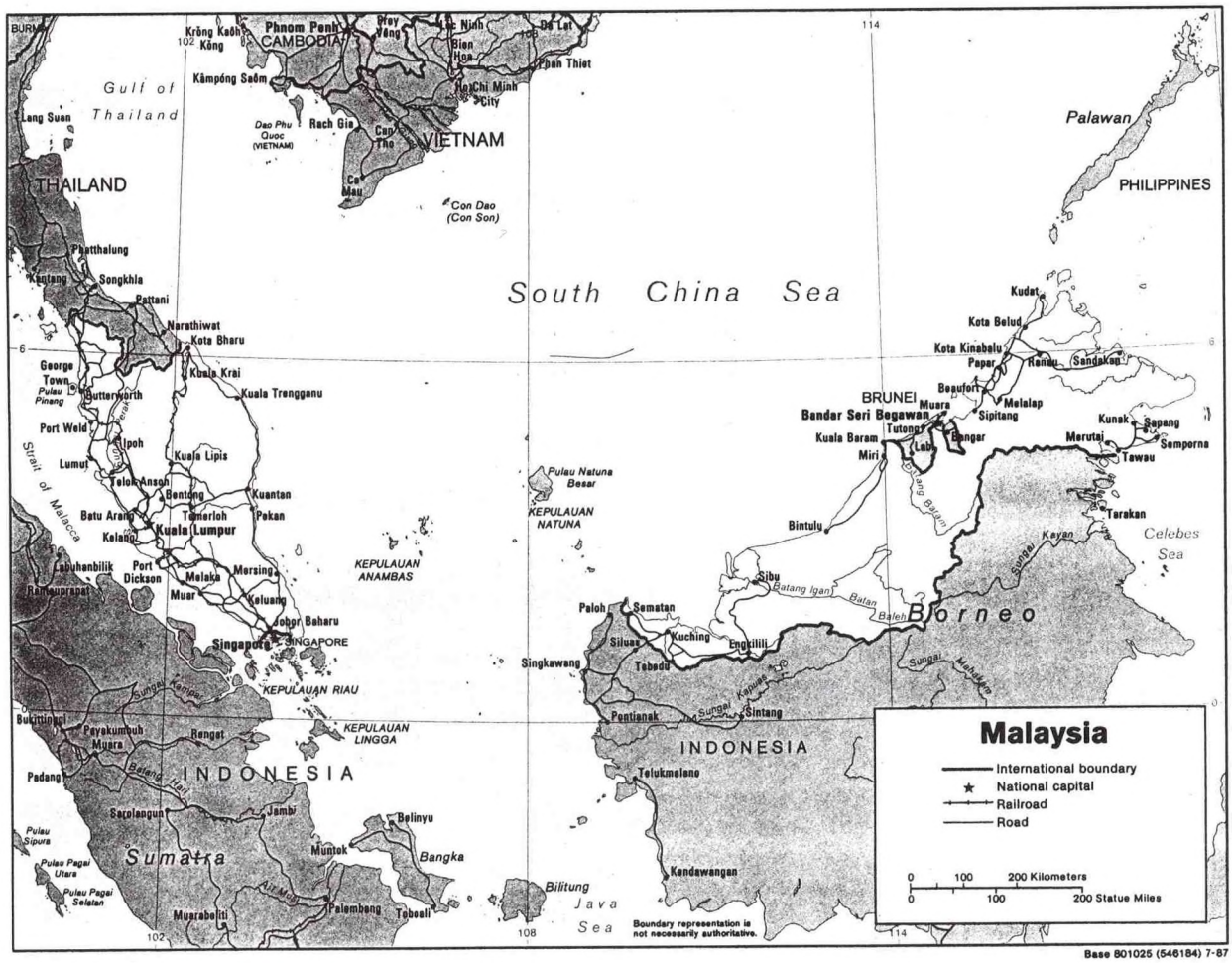


Figure 1.--Map of Malaysia.

annual production goal of 21,000 t by the year 2000. Many of the projects are joint ventures with Taiwanese partners. Some of the larger projects have their own hatcheries, and some are integrated with processing plants. Projects have been sited in Sabah, as well as the states of Johore, Pahang, Trengganu, and Kelantan on the east coast, and Selangor, Perak, and Kedah on the west coast of peninsular Malaysia (figure 1).

III. CORPORATE INVESTMENTS

Three major corporations have located projects within a very small area at Kuala Sedili, in the state of Johore. They are: the Johore State Economic Development Corporation, which runs the East Asia Marine Farms (EAMF); the Anglo-Dutch Unilever Corporation; and the Lion Corporation, which also has shrimp farms in Malacca and Sabah, through holdings of its subsidiary, Aquabio.

U.S. Embassy officials in Kuala Lumpur recently visited the EAMF project and talked with its managing director, Ahamad Bin Mohamed. EAMF produced 420 t of shrimp on 200 ha (50 ponds of 4 ha each) in 1988 and is predicting 1989 production of 660 tons. It is expanding its Kuala Sedili operation by another 200 ha and is building a 450 ha farm near Mersing, Johore, for $18 million. EAMF uses the semi-intensive culture method, which has consistently yielded 600-700 kilograms (kg) of shrimps per ha annually in Malaysia. However, EAMF achieved yields of 915 kg per ha in 1988 and is currently producing 1,200 kg per ha annually. The company's goal is 2,000 kg of shrimp per ha, and it already has some ponds producing above this rate. EAMF's harvesting cycle is approximately 4 1/2 months for each pond. Most of its efforts for increasing productivity are focused on reducing turnaround time; its equipment for cleaning and repairing ponds after harvesting becomes inoperable in the frequent rains.

EAMF currently imports shrimp feed from Taiwan but is constructing its own feedmill. Feed

accounts for about 60 percent of production costs in Sabah and 40-50 percent of production costs in peninsular Malaysia. Sabah has recently announced that it will embark on a feed mill joint-venture with an unnamed foreign partner.

EAMF is vertically integrated, with its own hatchery and processing plant. It would like to process shrimp from other projects, but currently a substantial percentage of Malaysian shrimp are shipped live for processing to Singapore, where they command higher prices. EAMF processes and freezes its shrimp for shipment to Japan, where they are marketed under the premium-brand name "Jason's Bay" and the general-brand name "Golden Island".

According to EAMF's managing director, the Kuala Sedili-based Unilever and Lion shrimp farms have just gone into production. At present, Lion's farm is producing 2 t per month, and Unilever is producing 1 t per month. Lion's shrimp farms in Malaysia are expected to harvest a total of 100-150 t in 1989. The company plans to expand from the current 40 ha in production to over 1,200 ha within the next five years. Press reports state that the Unilever project will eventually cover 1,000 ha (150 ponds), yielding 1,200 t per year. Unilever's total investment is expected to be $39 million.

The increased profitability of shrimp aquaculture in Malaysia is largely because of better siting. Previous projects often failed because ponds were located in mangrove areas where pond excavation resulted in a level of water acidity that is lethal to shrimp. In contrast, the Kuala Sedili projects are located on a tidal river at the edge of a mangrove area where the soil is more suitable.

Despite identical siting, however, there is strong disagreement among the three companies on the best production methods. The Unilever project has higher capital costs because the company lines its ponds with concrete and uses more expensive pumping equipment. The American farm manager for EAMF believes these costs are unnecessary, citing a previous Unilever failure in Sri Lanka. However, an industry source (not associated with any of the three companies) believes that EAMF and Lion risk failure precisely because their less expensive approach leads to costly pond maintenance and significant down-time.

Other than feed, the greatest expense for all three projects is the pumping of thousands of gallons of brackish river water in and out of the ponds to maintain proper oxygen levels and to flush them of waste. According EAMF's Ahamad, while the Government is still endorsing the use of mangrove and for aquaculture, the cognoscenti in Malaysian aquaculture will be setting up on sites similar to Kuala Sedili. The east coast is dotted with relatively unpolluted tidal rivers with adjacent state land theoretically available for aquaculture.

IV. HATCHERIES

At present, 32 shrimp hatcheries are registered with the Malaysian Fisheries Department (23 in peninsular Malaysia and 9 in Sabah). Pl production in 1987 was 300 million (240 million in peninsular

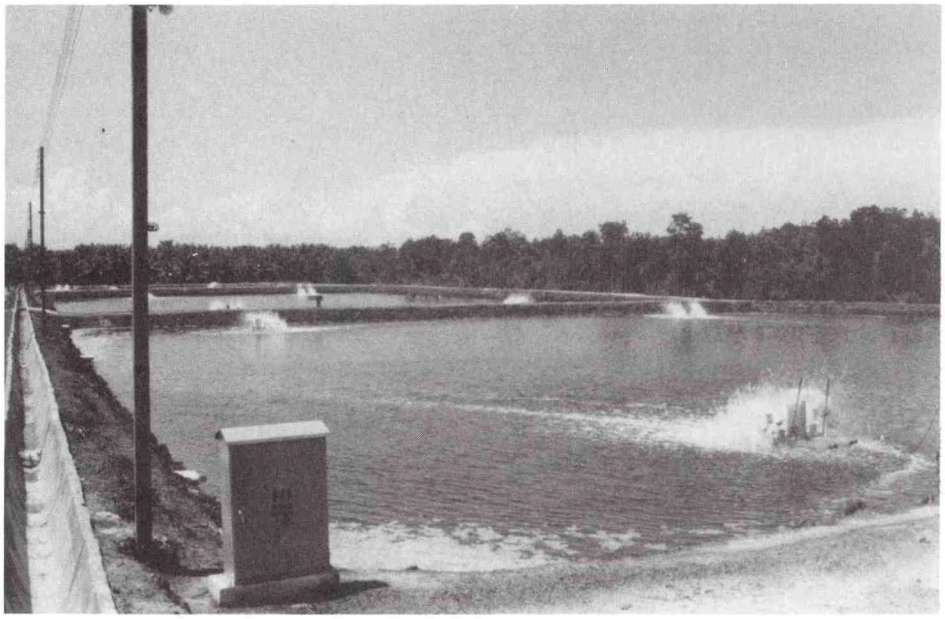


***Photo 1.**--Malaysian shrimp farm. ©Tarlochan Singh-Infofish*

Malaysia and 60 million in Sabah). Estimated 1988 pl production is 360 million (280 million in peninsular Malaysia and 80 million in Sabah). Although 78 million pl were exported in 1987, it is estimated that only about 11 million pl were exported in 1988. The reasons for this decline are not known. The major foreign markets for Malaysian pl are Sri Lanka, Oman, Pakistan, Hong Kong, Italy, China, and Thailand.

Sabah dominates production of wild tiger prawn broodstock in Malaysia. Live gravid females sell locally for between $58 and $110, with prices going as high as $1,820 in Taiwan, the major export market[2]. (Tiger prawns accounted for 70 percent of Taiwan's shrimp exports to Japan and 29 percent of Southeast Asia's shrimp exports to Japan in 1987.) Malaysia has banned the export of gravid shrimp, but smuggling them out of the country through Singapore is common.

V. RESEARCH

The Malaysian National Prawn Research Center was completed in 1987 with a $8.4 million grant from the Japanese Government. It has also received assistance from two Japanese aquaculture experts supplied by the Japanese International Cooperation Agency. The Center has cut shrimp pl production costs by 50 percent over the last five years, from $.015 per fry to $.007. A new technique for mass production of pl through induced spawning was developed at the Center and is being applied in most of Malaysia's hatcheries.

VI. GOVERNMENT INCENTIVES

The Malaysian Government assists the shrimp culture industry through the Department of Fisheries, which provides advice and technical assistance. Shrimp culture firms are also eligible to receive the tax rebates and tax relief, which the Malaysian Government provides to most developing industries. A 5 percent investment tax credit is extended to all shrimp culture investors, i.e. 50 percent of the first 5 year's qualifying capital expenditures may be deducted from taxable income. These expenditures include the clearing of land, pond construction, the purchase of plant and machinery, and building construction. Investors may also borrow from the Government's new low-cost investment fund at reduced rates or benefit from a reduced interest rate export credit refinancing scheme.

VII. OUTLOOK

Malaysia will be pushing to join the ranks of major Asian shrimp producers over the next ten years. Prospects are bright for continued investment now that the larger companies are beginning to demonstrate that shrimp aquaculture can succeed commercially in Malaysia. Whichever production method is employed, potential large players, such as plantation companies and state economic development corporations with foreign joint-venture partners, are likely to move into the shrimp culture business.

This report was originally prepared by Karen L. Kelsky and Paul Niemeier and published as IFR-89/50 on June 12, 1989.

SOURCE

U.S. Embassy, Kuala Lumpur, Malaysia.

ENDNOTES

1. *Penaeus monodon* are also marketed commercially as black tiger prawns.

2. The official exchange used in this report is U.S.$1.00 = M$2.75.

APPENDIX

Appendix. -- Malaysia. Total shrimp production, by fishery, with cultured shrimp as percentage of total shrimp production, 1983-1988, and 2000 projection.

Year	Fishery			Percent*
	Wild Catch	Cultured	Total	
		--Metric tons--		
1983	52,821	415	53,236	1
1984	53,650	682	54,332	1
1985	80,349	205	80,554	Negl.
1986	57,982	269	58,251	Negl.
1987	71,693	1,260	72,953	2
1988E	N/A	1,800	N/A	N/A
2000P	N/A	21,000	N/A	N/A

* - Cultured shrimp as percentage of total.
N/A - Not available.
Source: U.S. Embassy, Kuala Lumpur, FAO Yearbook.

3.5

PHILIPPINES

Philippine aquaculturists produced an estimated 50,000 metric tons (t) of black tiger shrimp in 1989, accounting for about 8 percent of the world farmed shrimp harvest. The Philippine shrimp culture industry has expanded each year since the early 1980s, but has not increased as explosively as in several other Asian countries. Some investors and multinational companies have established high-yield shrimp farms in the Philippines, using the most advanced aquacultural technology, but many Filipinos are farming shrimp on a more primitive level, relying on methods that Philippine fish farmers have used for centuries. As a result, there is a gulf between high-yield intensive and semi-intensive farms, on one hand, and lower-yield extensive farms, on the other. The two types of farms not only produce vastly different quantities of shrimp per hectare of pond, they also face disparate technical and economic constraints. In 1990, both types of Philippine shrimp farmers were still recovering from the losses suffered the previous year, when farmgate prices for shrimp decreased by over 50 percent. The future of the industry remained unclear as of mid-1990, but it appeared that Philippine shrimp farmers would have to adopt the most cost-efficient production methods to survive in an increasingly competitive world shrimp market.

CONTENTS

I. INTRODUCTION

The Philippines was the world's eighth largest producer of fishery products in 1988; the harvests from both wild fisheries and aquaculture reached 2.3 million tons. The most important wild fisheries,by quantity, were horse mackerel, anchovies, sardines, and tuna. Although the fishing industry is large, it is not highly modernized. Over half of the wild catch derives from artisanal fishing (using vessels smaller than 3 gross registered tons) in and around the 7,000-island archipelago (figure 1). Fishery products are the major source of protein for most Filipinos; per capita consumption is estimated at 30 kilograms (kg) per year.

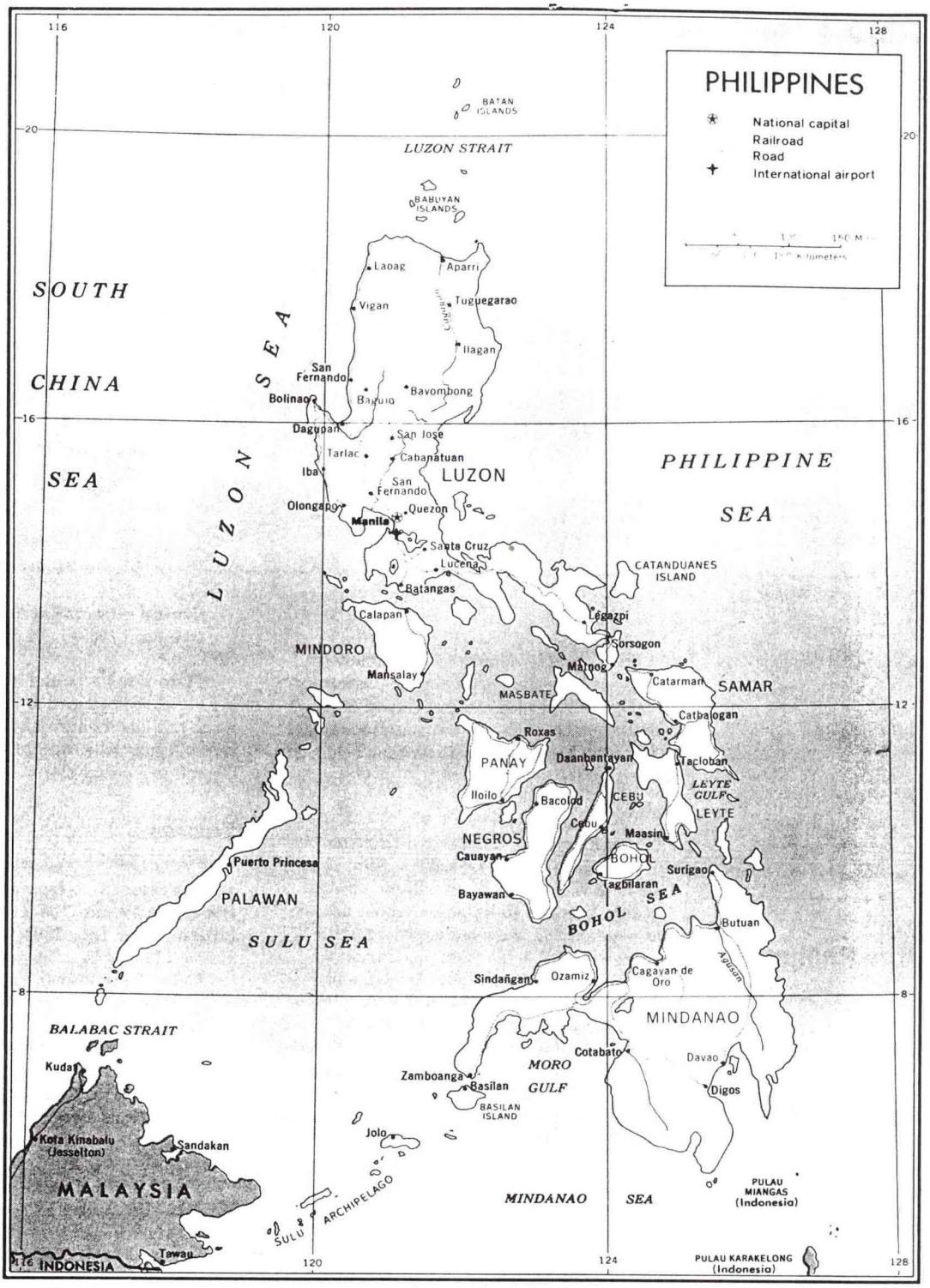


Figure 1. *Map of the Philippines.*

Philippine aquaculture, like the fishing industry, is a mixture of artisanal and commercial enterprises. For many decades, most aquaculturists raised milkfish (also called bangus, or *Chanos chanos*) in shallow earthen growout ponds and in estuaries. Milkfish were suitable for such simple cultivation because they easily adapted to varying levels of salinity and temperature. Production peaked at 250,000 t in 1982, making milkfish the nation's single largest fishery. Production levels were limited primarily by the number of fry that could be collected in coastal waters. Fishermen waded into shallow water with nets to catch fry, or trapped the juvenile milkfish in estuaries at high tide. The commercial potential of milkfish farming was also limited; the fish were produced mainly for the low-value domestic market.

Shrimp aquaculture was practiced for many years in association with milkfish farming, but only as an incidental activity. Fishermen inevitably caught young shrimp (also called post-larvae, or pl) when they collected milkfish fry, because both shrimp and milkfish spawn in coastal waters. Alternatively, shrimp pl entered estuaries at high tide, and were trapped along with milkfish fry. Shrimp matured along with the milkfish and were harvested as a byproduct. Thus, the widespread farming of milkfish in the Philippines (an estimated 200,000 hectares (ha)[1] of farms operated in the early 1980s) meant that shrimp harvests were also widespread. Such polyculture, however, produced only small quantities of shrimp.

The bulk of Philippine shrimp production came from wild fisheries until the mid-1980s (fig. 2). Philippine fishermen developed a major shrimp fishery in the 1960s and 1970s, catching mostly white shrimp and tiger shrimp (nomenclature in table 1) in Manila Bay, Lingayen Gulf, Ragay Gulf, San Miguel Bay, Panguil Bay, and the central seas (fig. 1). As in other Asian nations, the wild shrimp stocks declined or at least stabilized in the face of intense fishing pressure. In addition, rising fuel prices after 1973 increased the cost of fishing. By the time the wild shrimp catch reached its peak in 1986, increasing numbers of Filipinos (like other Asians) were turning to shrimp aquaculture.

Philippine shrimp culture gained ground on the wild shrimp fishery during the late 1980s, and may have surpassed it in 1989 (appendix 1). Two factors (besides the stagnating wild catch) prompted Filipinos and other Asians to concentrate on cultured shrimp production. First, advances in technology made shrimp farming more viable. Commercial-scale shrimp farming became possible in the 1980s because of research conducted in the 1970s and earlier. One by one, technical obstacles to shrimp farming were overcome. Farmers and researchers in the Philippines and elsewhere learned to build and maintain shrimp ponds, produce larvae, and enhance shrimp growth by using artificial feeds. In the Philippine case, there was a significant influx of shrimp farming technology from Taiwan. A second factor was the high price of cultured shrimp, which held out the prospect of good profits for farmers. In late 1984, for example, wholesale prices for cultured shrimp in the Philippines stood at over US$10 per kilogram (kg), 5 times the price of milkfish. Remarkably, the shrimp production costs were reported to be lower than those of milkfish. Black tiger shrimp became the species of choice for Philippine aquaculturists because it had been successfully farmed elsewhere, and because it could be readily exported to Japan.

The influx of technology and expertise from Taiwan and elsewhere spurred the development of shrimp aquaculture in the Philippines. But not all farmers adopted advanced production methods. Instead, following a pattern that marked the development of shrimp aquaculture throughout Asia,

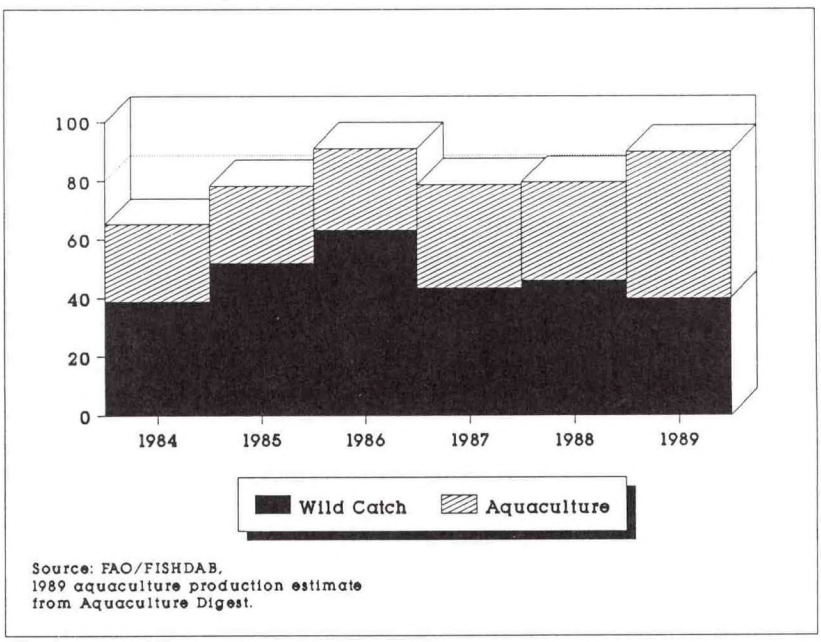


***Figure 2**--Philippines. Shrimp production, 1984-89.*

Table 1.--Philippines. Important shrimp species.

Species Name		
Common	Philippine	Scientific
(Black) tiger shrimp	sugpo	P. monodon
White shrimp	hipong puti	P. setiferus
Sergestid shrimp	suache	Sergestidae
Paste shrimp	alamang	Acetes japonicus

the shrimp farming boom in the Philippines proceeded along diverging routes (section II, A).

Intensive Culture: On the high-technology end of the spectrum, farmers constructed small cement ponds, stocked them with large numbers of hatchery-raised shrimp pl, carefully controlled the salinity and aeration of the water, and fed the growing shrimp artificially formulated feed (photo 1). These so-called intensive farms yielded crops as large as 10 t per hectare; 2 or 3 crops per year from the same pond were possible. As long as shrimp prices remained high, farmers quickly recovered their substantial investment and production costs and earned impressive profits.

Extensive Culture: Far removed from the intensive farms were the traditional, or extensive shrimp farms. Many of the latter were created when milkfish farmers converted their shallow ponds directly to shrimp culture, perpetuating the artisanal character of Philippine aquaculture. Such conversions required minimal expenditures. Farmers deepened their ponds to about 1 meter and collected (or purchased) shrimp pl instead of milkfish fry. The algae that naturally grew in the ponds served as feed. Rainwater, or other naturally occurring freshwater sources, served to maintain the proper range of salinity. Yields were relatively low in these extensive operations, under 0.5 t per hectare, and usually only 1 crop could be produced per year. On the other hand, production costs were also low, since no artificial feed or sophisticated equipment was required.

Semi-intensive Culture: Between the two extremes there were various types of semi-intensive farms, incorporating elements of both types of operations.

Care should be given to assessing the difference in shrimp culture methods. Some observers view the intensive approach, with its high yields, as most efficient. While extensive farms may produce far lower yields, the low technology approach may be most suited for countries, such as the Philippines, that have recently begun to develop shrimp culture industries. Extensive farms have often proven the most cost-efficient, and thus the most profitable, because they can be established with minimal capital investment and can be managed using locally available technology. It is not yet clear whether this is the case in the Philippines.

The distinction between extensive and intensive shrimp farms is not unique to the Philippines, but it is a noteworthy feature of that nation's shrimp farming industry for several reasons. First, the two types of farms (actually many types, when semi-intensive farms are included) clearly face different technical constraints. Besides producing vastly different quantities of shrimp per hectare, the farms require significantly different equipment, expertise, and day-to-day management. The most traditional extensive farms are highly dependent on natural phenomena: wild pl supplies for stocking, algae for food, and the proper amount of rainfall. Intensive farms are less vulnerable to these variable factors, but their high shrimp-stocking densities make them more susceptible to disease. (The latter problem was dramatically demonstrated when disease struck many of Taiwan's intensive farms in 1988.) Besides having a different degree of dependence on the surrounding environment, the two types of farms also have different effects on that environment. For example, the enlargement of extensive farms is said to damage coastal mangroves, while the use of well water by intensive farms threatens the water table. Thus, while members of the industry are concerned about which type of farm, extensive or intensive, is the most efficient way to produce shrimp, other Filipinos are wondering which type of operation is most compatible with the fragile coastal environment.

Closely connected with the technical distinctions between extensive and intensive farms are economic distinctions. Intensive operations clearly require larger initial investments and generate higher operating costs. Fluctuations in interest rates, feed prices, or feed costs can have a major impact on intensive farms. In the Philippines, such farms were highly profitable when shrimp prices were high, but were hardest hit when black tiger prices plummeted in 1989 (section III). The effects of that price decline were still being felt among both extensive and intensive farmers in 1990. Many of the former had reportedly opted out of shrimp aquaculture, at least temporarily, in favor of milkfish or other farmed

species. Many of the latter were trying to service large debts incurred when shrimp prices were high. The era of easy profits for shrimp farmers seemed to be over. Several observers characterized 1989-90 as a weeding-out period, after which only the more efficient farms would remain in operation. As of mid-1990, it was not yet clear whether the dominant approach would tend to be extensive, semi-intensive, or intensive. It was clear, however, that economic factors--primarily the world price for black tiger shrimp--would markedly affect the future course of shrimp farming in the Philippines.

While its future direction was not yet clear as of mid-1990, the growing impact of shrimp farming on the Philippine economy could not be dismissed. Shrimp, over half of which came from aquaculture, has become the nations's most successful fishery export and one of the largest exports overall (section IV). Apart from its impact in strictly monetary terms, the industry is significant because it cuts across many different socio-economic levels. Shrimp aquaculturists range from individual low-income farmers looking for a cash crop, to wealthy Filipinos, to large companies seeking to enter the growing world shrimp market. Shrimp farming contributes to rural development and supports a significant number of jobs in other fields, such as transportation and processing. Furthermore, shrimp farming is proving to be a catalyst for foreign investment and joint-venture enterprises in the Philippines, where economic development is a priority.

This report provides a basic overview of the shrimp farming industry in the Philippines, emphasizing current information whenever possible. The report is but an incomplete description of the industry, because comprehensive data, such as nationwide surveys, are not readily available, and because the industry is still changing rapidly. In section II, production levels and technical aspects of shrimp aquaculture are discussed. Section III raises some of the economic issues facing farmers, especially in the wake of the price instability that afflicted the industry in 1989. Section IV describes Philippine shrimp exports, including the recent growth of such exports to the United States.

II. PRODUCTION

The Philippines produced an estimated 50,000 t of cultured shrimp in 1989 (appendix 1 and fig. 2), or about 8 percent of the world's supply (fig. 3). Asian

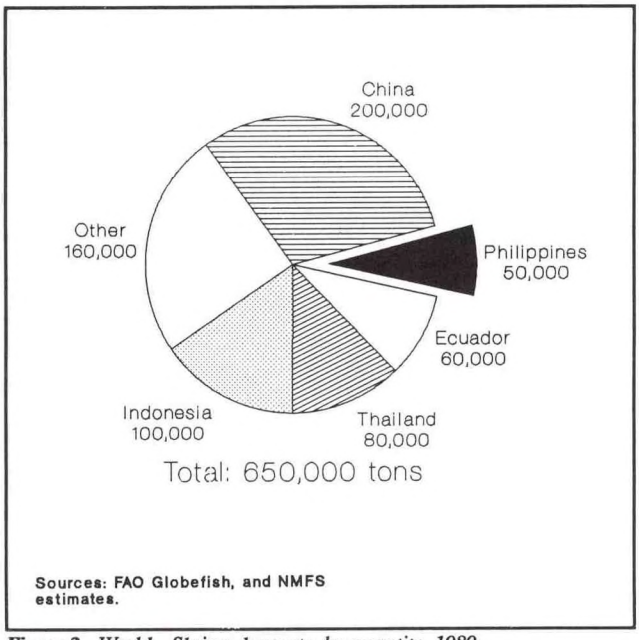


Figure 3.--World. Shrimp harvests, by quantity, 1989.

nations, led by China, Indonesia, and Thailand (and by Taiwan until its production collapsed in 1988), have become the world's leading producers of farmed shrimp, spearheading the large production increase since the mid-1980s. World farmed shrimp output tripled from 210,000 t in 1985 to about 650,000 t in 1989. As a result, farmed harvests in 1989 accounted for about one-fourth of world shrimp supplies.[2]

The explosive growth of shrimp farming, and the recent tendency toward lower shrimp prices, are having a profound effect on shrimp farming in the Philippines and elsewhere. Many Philippine farmers apparently abandoned shrimp farming (perhaps only temporarily) in 1990 because of the disastrous 1989 price decreases. According to a U.S. importer who is familiar with the Philippine industry, this reluctance on the part of farmers will lead to 1990 shrimp harvests considerably smaller than in 1989--possibly under 40,000 tons. Actual production levels for the year remain to be seen, and favorable prices may persuade farmers to reenter the industry in late 1990 and 1991. Nevertheless, farmers are now being forced to become more efficient or leave the industry.

A. Farm Types and Locations

There are three main production systems used in shrimp culture (table 2). Aquaculture experts typically refer to the systems as (1) extensive, (2) semi-intensive and (3) intensive, although the precise definitions of each type of farm vary.

Table 2-Philippines. Shrimp production methods.

	Extensive	Semi-Intensive	Intensive
Stocking Density (1,000 pl/ha)	5-30	30-200	200-500
Pond Size (ha)	more than 1		less than 1
Feed Type	natural	artificial	artificial
Aeration*	no	maybe	yes
Water Supply	tidal/rain	pumps	pumps
Yield (kg/ha)**	500 or less	500-3,000	3,000-10,000

* Sometimes accomplished through water circulation.
** Assuming 30 gram shrimp at 50 percent survival rate (conservative estimate).

(1) Extensive system: This most traditional system uses tidal flow and rainwater to change pond water. Natural pond growth (algae) is used as food; little or no supplemental feeding is done. Stocking densities are relatively low: from 5,000-30,000 pl per hectare. Average shrimp production is less than 0.5 t per ha per crop, but the low maintenance level allows farming in ponds covering several hectares. A crop may take over 6 months to reach harvestable size. The long growout period and the dependence on seasonal rains to achieve proper salinity usually means that only one crop is harvested per year.

Extensive shrimp farms are located throughout the Philippine Archipelago, but are most concentrated on the Island of Panay, where Philippine shrimp farming began. Aside from milkfish ponds, both rice and sugar farms on that island have been converted to shrimp farms. Most ponds are surrounded by earthen dikes and many are located in areas accessible only on foot, making rapid transportation of harvested shrimp to processing plants a challenge.

(2) Semi-intensive system: This broadly defined system uses tidal movement and pumps for water exchange. It depends on supplemental feeding in addition to food naturally produced in the pond. Production costs are significantly higher than in the extensive system because of the use of manufactured feeds, chemicals, and water pumps. The semi-intensive system uses shrimp fry stocking densities from 30,000-200,000 pl per hectare. Average shrimp production varies from 0.5 t to 3.0 t per ha for each crop. Usually two crops can be produced per year.

Examples of recently established semi-intensive farms include a 5-ha venture launched in mid-1989 in the town of Quezon, north of Manila. The owner, who purchased a total of 75 ha from the Philippine Development Bank, planned to stock the first ponds with 50,000 pl per hectare. The U.S. Embassy in Manila reports that a typical shrimp farm, beginning operation in 1989, was semi-intensive. Stocking densities of 100,000-155,000 pl per hectare were preferred because many producers using higher densities had encountered disease problems.

(3) Intensive system: This method operates on a closed system with an external source of fresh and salt water. The water in the pond must be changed frequently, and the water quality strictly controlled, requiring high energy inputs. Most, if not all, food is in the form of pelletized feeds. Shrimp fry stocking density ranges from 200,000-500,000 pl per hectare. Average shrimp production varies from 3.0-10.0 t per ha for each crop.

Intensive farming began in the Philippines in 1981, when the San Miguel Corporation, one of the nation's largest companies, converted a sugar plantation on the Island of Negros into a shrimp farm. The company set a strong example for other farmers by 1983, when it harvested 3 crops, achieving a production level of 12 t per hectare. Besides proving that intensive shrimp farming was feasible in the Philippines, the company also directly encouraged the expansion of shrimp aquaculture by entering into contract agreements with local farmers, and by providing them credit and training.

By the late 1980s, there was a large concentration of intensive farms on the west coast of the island of Negros, where the level of investment in shrimp farming is much higher than on neighboring Panay. The shrimp ponds on Negros are usually made out of cement, are accessible by truck, and are often patrolled by armed guards. Intensive farming is said to have taken root not only because of the role of the San Miguel company, but also because wealthy families on Negros Island could afford to pay high start-up costs. Recent reports indicate how high such costs can be. A 20-ha intensive farm in Santa Catalina, Negros, was slated to open in July 1989 after the First Philippine Holding Corporation invested US$5 million in the operation. It features 10

concrete ponds and is expected to produce as much as 400 t of shrimp per year. The corporation plans to invest another US$10 million to build a modern hatchery, vertically integrating the shrimp raising complex.

Intensive farms have been established on other islands as well. One example is a large 180-ha farm in Sarangani Bay, southern Mindanao, launched in 1988 by the Dole Philippines company. The US$12 million project (about US$85,000 per hectare) adopted Taiwanese technology, and may include a joint-venture agreement with a wealthy Philippine family (Alcantara). Another promising intensive operation is a 0.9-ha farm in Panguil Bay, Mindanao, whose owners harvested over 8 t of shrimp per hectare in 1987. Shrimp Specialists, Inc., the operators of the Panguil Bay farm, indicate that they used stocking densities of 200,000 pl per ha and achieved an astonishing 94 percent survival rate after a 135-day growout period.

Overall statistics on the quantity and type of shrimp farms in the Philippines are not readily available from the Philippine Government, or from other official sources. Most Philippine aquaculturists appear to be at best well-informed only about the state of the shrimp farms on their island; communications between islands are sporadic. Thus, estimates of the overall state of the industry must be tentative. One industry representative reported in mid-1990 that there were 400,000 ha of extensive and semi-intensive shrimp farms (many of which were previously used for raising milkfish, see p. 2 for details), and about 4,000 ha of intensive farms. As for the number of shrimp farms, a 1989 report estimated their total at 3,000. Intensive and semi-intensive farms, though relatively few in number, reportedly produce almost half of the nation's farmed shrimp.

B. Post-larval Supply

The supply of pl has long been a factor limiting farmed shrimp production. For many years, shrimp farmers in the Philippines relied exclusively on pl caught at sea or collected in estuaries. Many extensive farmers still do. Wild-caught pl are inexpensive if the farmer catches his own, but their supplies are irregular and the survival rate of pl caught at different times is said to vary. The pl are most abundant in coastal waters during the northeast monsoon, from November to January, and during the southwest monsoon, from June to August.

Shrimp farming advanced after 1979, when the first commercial shrimp hatchery opened in Bacolod City, on the island of Negros. Operated by the Pioneer Aquaculture Company, the hatchery relied on ocean-caught gravid (pregnant) females to produce millions of eggs (each gravid shrimp can produce as many as 1 million eggs). The eggs, or nauplii, went through several stages within their first 3 weeks of life; they could then be sold as pl to farmers and placed in growout ponds.

The number of hatcheries increased rapidly during the 1980s. By 1983, hatcheries supplied about 100 million pl, or over 80 percent of the pl supply. Hatcheries were a boon to farmers because they produced a steady and uniform supply of post-larvae. There were an estimated 380 hatcheries producing black tiger pl in 1988.[3] Like the shrimp farms, the hatcheries ranged in size from the hundreds of small backyard operations (producing less than 1 million pl per month) to the 20-30 commercial enterprises (producing 5-10 million pl per month). A 1989 survey reported that there were 91 small hatcheries operating just on southwestern Panay island, twice as many as in 1988. Large hatcheries included one in Zambales Province, on the main island of Luzon, established in 1989 as a joint venture between Hawaiian Hatcheries company and several Philippine investors. This venture was slated to produce 100 million pl per year--roughly equivalent to the nation's entire pl output in 1983. In a related trend, the largest intensive shrimp farms, which depend on high pl stocking densities to maximize output and profits, have built their own hatcheries. International organizations and the Philippine Government also operate several pl hatcheries. As of mid-1988, these included 2 Southeast Asian Fisheries Development Center (SEAFDEC)[4] hatcheries on Panay, and 3 Government hatcheries on the Island of Mindanao.

Although hatcheries partially eliminated one bottleneck for shrimp farmers, namely the pl supply, most Philippine hatcheries still depend on the sometimes irregular supply of ocean-caught gravid shrimp. Such spawners have become valuable commodities. A single one cost over US$50 in 1988, and it is illegal to export them from the Philippines. Some of the most modern hatcheries, such as one operated by the Purefoods company in Zambales Province, on Luzon, have overcome this obstacle to pl production by breeding spawners.

C. Feed Supply

All but the most extensive shrimp farms in the Philippines now depend on artificial feed to promote rapid shrimp growth. Shrimp feeds usually consist of animal and vegetable proteins, fats, carbohydrates, and assorted vitamins and minerals, often in the form of a pellet with a water soluble coating. Wheat flour and soybean meal are major ingredients, suggesting that U.S. agricultural exporters could supply raw materials for the Philippine feed industry.

There were about 21 shrimp feed plants operating in the Philippines in 1990, producing about 100,000 t of feed per year, and reportedly supplying about 85 percent of shrimp farmers' needs. The San Miguel company, which is active in all phases of the shrimp farming industry, is the largest feed producer in the Philippines. The company reportedly helped 3,000 farmers remain in business during 1989 by providing discounts on feed.

Most shrimp feed was imported into the Philippines from Taiwan until the late 1980s, when the San Miguel company became a major domestic producer. A continuing sign of the Taiwanese presence in the Philippine market is Santeh Feeds, a 1990 joint venture between the Santa Monica group in the Philippines and the Taiwanese Tateh Agricultural Industry. The latter company is a major exporter of feed to the Philippines. Santeh's plans in the Philippines are ambitious: the company expects to capture 15-20 percent of the shrimp feed market, and also hopes to export feed to Indonesia and other Asian countries with shrimp farming industries.

Despite the expansion of feed manufacturing in the Philippines, the quantity of feed imports is still significant. Some farmers complain that Government policies that were intended to promote the domestic feed industry, such as high tariffs (about 20 percent) on imported feed, raise the domestic cost of feed and thereby raise shrimp production costs. The Government reacted to these concerns in 1989, when it temporarily suspended the import tariffs. (As of this writing it is not known whether the tariffs have been reinstated).

The Philippine Department of Agriculture ruled in 1990 that shrimp feed bag labels must contain the following information, in addition to a listing of the contents: expiration date of the product, recommended storage conditions, and maximum peroxide and aflatoxin (a toxin produced by mold or fungus) contents. Some members of the Association of Philippine Prawn Feed Millers have protested the new requirements, which are stricter than those applied to other animal feeds, contending that there are no established standards determining the acceptable levels of these impurities. They also maintain that these strict regulations are not enforced on feed imports.

D. Processing

There were an estimated 39 shrimp processing plants in the Philippines in early 1989, 12 of which first began operating in 1988. Six additional plants were expected to open by 1990.[5] A typical processing plant--where shrimp are sized, cleaned, deheaded, and quick-frozen--employs 50-100 women. The jobs created in this way are considered analogous to sewing jobs in the textile industry since they employ workers who most likely would not otherwise have a monetary income. In addition, processing plants in rural areas are a first step towards an expanded industrial base.

The U.S. Embassy in Manila reports that an interesting synergy has developed between intensive shrimp producers on Negros Island and processors on neighboring Panay Island. The connection first emerged in 1986, when a major processing plant opened in Iliolo City (Panay), giving the island an excess of processing capacity. The processing plant, funded by the Philippine Fisheries Development Authority, housed 5 companies (Purefoods, Ammcor, Agribase Ventures, Ercer, and General Marine) that together could process 12-15 t of shrimp per day (or 4,300-5,400 t per year). As recently as 1988, two-thirds of the shrimp processed at the plant, which employed about 600 workers, came from Negros Island, where the shrimp farming industry had expanded much more rapidly than on Panay. The daily shipment of almost 10 t of shrimp from Negros to Panay placed heavy demands on inter-island transport and encouraged private and commercial shippers to acquire additional vessels. Despite the construction of shrimp processing plants on Negros Island, which could reduce shipments to Iliolo City, the Panay processing plant was expected to double its capacity by 1990.

Several large shrimp-farming companies have recently established shrimp processing facilities. San Miguel Corporation opened its third processing plant in 1989 in Bacolod City, Negros Island. The plant has the capacity to process 1,800 t of shrimp a year,

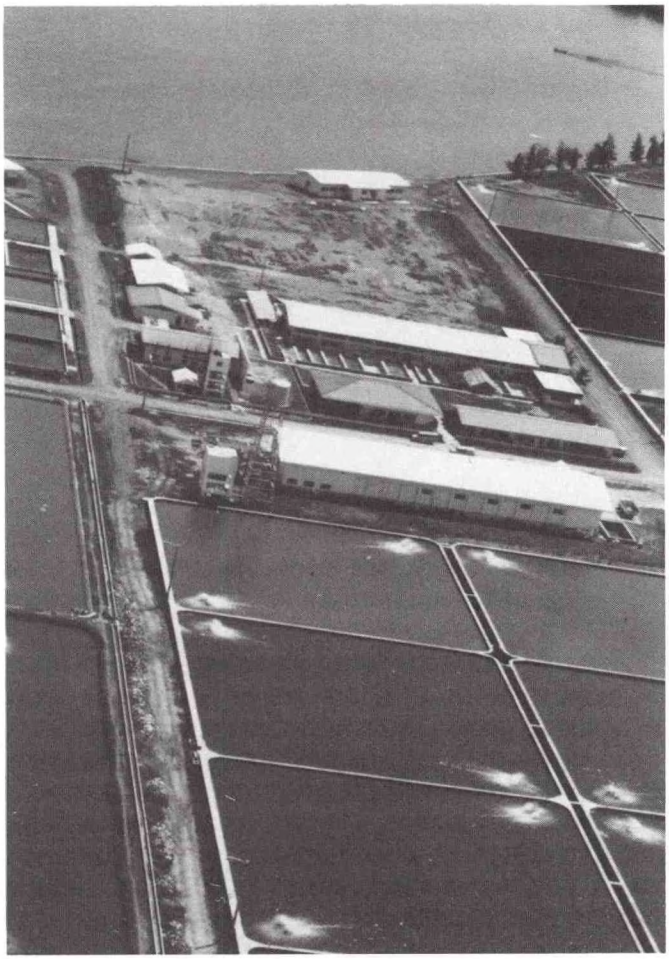


***Photo 1.**--Philippines. San Miguel Company hatchery, processing plant, and ponds. Negros, Philippines. © Henry R. Branstetter.*

presumed to come from the company's own farms, using advanced sorting technology ("Sort-Rite") bought in the United States. The first San Miguel plant opened in 1983 in Calatrava, also on Negros island (photo 1.). It was built with the assistance of Japan's Taiyo company, which gained the right to market San Miguel company shrimp in Japan. The second plant, which opened in 1988, is located in San Fernando, Luzon Island. In early 1990, the Dole Philippines company inaugurated a 5,000-t annual capacity processing plant in the southern part of Mindanao Island, where Dole also has a large intensive shrimp farm. The entire output from the plant was to be exported to Japan.

E. Research

The Philippines does not have extensive shrimp aquaculture research facilities; its shrimp farms rely primarily on technology and expertise developed in other countries. However, the islands do benefit from the presence of SEAFDEC's Aquaculture Department. The aquaculture center, located in Iliolo Province, Panay, was established in 1973 as one of three SEAFDEC departments (the other two are the Training Department in Thailand and the Marine Fisheries Research Department in Singapore). Researchers at the center conduct research on fish and shrimp aquaculture, train aquaculture workers, and disseminate information. One SEAFDEC program helped many farmers on Panay island set up their own small pl hatcheries. Other useful research studied the effect of antibiotics on various types of bacteria, and the effect of storage temperature on shrimp feed.

Another international organization that conducts aquaculture research in the Philippines is the International Center for Living Aquatic Resources Management (ICLARM). Recent ICLARM studies in the Philippines have focused on the use of artificial feed for aquaculture. The studies reflect the growing concern over efficient production methods. Instead of devising a feeding plan based simply on the most rapid shrimp growth rates, the ICLARM researchers stressed adjustments of feed composition (protein content) and a feeding schedule that would have the lowest costs and provide the highest net return to farmers.

F. Environmental Impact

There is growing concern in the Philippines about the harmful effects of shrimp farming on the environment. One problem is the destruction of coastal mangrove forests, which are important breeding grounds for many species of fish and shellfish. According to one report, the area of mangrove forests in the Philippines has been slashed by 75 percent over the past 2 decades, from 448,000 ha in 1968 to only 110,000 ha in 1988.[6] Most mangroves were cleared so that shrimp or other fish farms could be built. Some Filipinos are urging the Government to place a moratorium on the construction of shrimp farms in mangrove areas.

A potentially more serious problem is the effect of semi-intensive and intensive shrimp farming on the freshwater supply in the Philippines. Shrimp farming requires brackish water (a mixture of fresh and salt water) that must be periodically adjusted, drained, and exchanged. Extensive farms rely on rainfall and streams to achieve the proper salinity. But semi-intensive and intensive farms require a steady supply

of fresh water, so that contaminants do not accumulate in the densely stocked shrimp ponds. Many intensive shrimp farmers rely on wells to provide fresh water, and the growing use of such wells is placing increased demands on underground aquifers. When fresh water is removed from the aquifers, salt water tends to seep in. Pumping water from underground has also reportedly caused the ground to sink in places. A related issue is the drainage of water from shrimp ponds. Together with sugar mills, shrimp farms are said to be releasing large quantities of polluted water that threaten to poison the surrounding agricultural land.

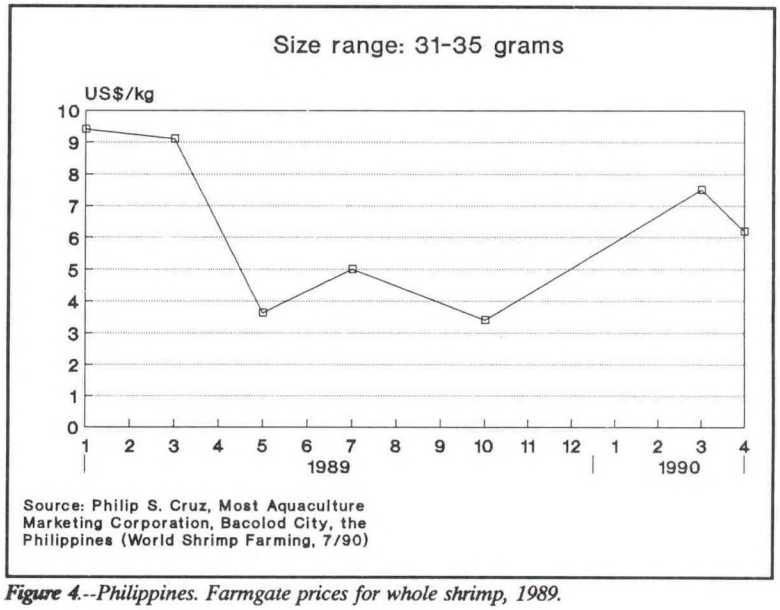


Figure 4.--Philippines. Farmgate prices for whole shrimp, 1989.

III. ECONOMIC ISSUES

Philippine shrimp farmers entered the technically difficult field of shrimp aquaculture expecting to earn large profits. As recently as early 1989, most farmers were fulfilling that expectation. During January 1989, for example, the owner of a 1-ha semi-intensive farm producing 5 t of shrimp per year per hectare (2 crops, each 2.5 t) could expect to gross as much as US$45,000, at the prevailing price of US$9.00 per kilogram (fig. 4). The average rice farm, by comparison, grossed only US$15,000-$20,000 per ha, and the average sugar farm even less.[7] Exact production costs for shrimp aquaculture for early 1989 are not available, but during 1987-1989 Filipinos reportedly could cover the original investment costs of a farm in one or two years, and could then grow one crop per year to cover costs and a second for profit. Thus, semi-intensive farmers who had covered their original investment costs were earning estimated annual profits of about US$20,000 per hectare--an impressive return by any standards.

The situation changed dramatically during 1989.[8] Farmgate prices for shrimp collapsed from over US$9.00 per kg in March to under US$4.00 in May (fig. 4). The reduced prices, which were apparently a result of increased regional competition among several Asian shrimp producers (section IV, p. 10), cut deeply into farmers' profit margins. Production costs for intensively farmed shrimp (31-35 grams live weight) were reportedly US$3.40-3.90 per kilogram. Farmers on Negros Island, a majority of whom had borrowed money to finance pond construction and equipment, faced production costs closer to US$5.00 per kilogram. Some of these farmers suffered substantial losses. Half of the intensive farms ceased operations, at least temporarily, by the end of 1989.

Extensive farmers, with production costs in the US$1.50-$2.50 per kg range, were not as hard hit by the price decrease. Nevertheless, many stopped raising shrimp when prices became unfavorable. Other extensive and intensive farmers resorted to raising only large sizes of shrimp, for which prices remained high. The farmgate price for 61-65 gram shrimp was about US$8.20 per kg in October 1989. Such large shrimp required a growout period of 180-200 days, however, negating the possibility of two crops per year.

The sudden price collapse of 1989 shook the entire Philippine shrimp industry. Hatcheries and feed companies reported severely reduced sales. Hatchery prices (usually for 20-day old shrimp) stood at US$12.00 per thousand pl during the first quarter of 1989, but decreased by 50 percent during the year. About half of the 20 feed companies operating at the beginning of 1989 had closed by the end of the year. Monthly feed sales for one remaining company dropped by two-thirds from March to December.

The Philippine shrimp farmers who remained in business during 1989 were forced to cut costs and produce more efficiently. Production costs reportedly decreased 15-25 percent by the end of the year. Farmers took advantage of cooperatives when purchasing supplies, reduced their use of chemical

additives and antibiotics, cut back on their use of fuel for pumps and aerators, and made use of supplemental feeds such as unmarketable mollusks and trash fish. As a result of these scaled-back production methods, stocking densities also had to be reduced, to prevent loss of shrimp to disease. Thus, even though prices partially recovered by the end of 1989, the era of huge profits for Philippine shrimp farmers may have ended. Based on the continued growth of shrimp farming in other countries, Philippine farmers may well face future price declines in an increasingly competitive market.

The effects of the 1989 price disturbance were still being felt in mid 1990. While some observers reported that farmers had reacted favorably to the price increase, restocking their ponds with shrimp pl, others maintained that large numbers of Filipinos had opted out of shrimp business in favor of farming other species. Early 1990 summer harvests were lower than predicted, according to preliminary reports, but this could be because farmers have decided to raise larger shrimp. The operators of one semi-intensive farm on Mindanao Island reported favorable results for the first 5 months of 1990. The farmers stocked their 7 ponds at 170,000 pl per ha, and harvested 5.15 t per ha after a 134-day growout period. The shrimp, averaging 32 grams each, were sold to the Dole Philippines company for US$5.34 per kg. Profits were calculated at a respectable US$2.74 per kg (or US$14,000 per ha). Production costs were US$2.60 per kilogram.[9]

As the above example shows, some shrimp farmers are still thriving in the Philippines. At the same time, however, the events of 1989 seem to have cooled the shrimp-farming fever that gripped the Philippines for several years. Future investments in the Philippine shrimp industry must consider the possibility of fluctuating international shrimp prices.

IV. EXPORTS

About 30 percent of the wild-caught and cultured shrimp in the Philippines is exported. The rapid expansion of shrimp exports (appendix 2) and the high value of shrimp per kg has made it the Philippines' leading fishery export, reaching a value of over US$250 million in 1988 (fig. 5), compared to US$35 million in 1984. Besides leading the fisheries sector, shrimp was the fifth largest Philippine export overall in 1988, behind textiles, semi-conductors, copper products, and coconut oil. (See appendices 3 and 4 for names and addresses of Philippine shrimp exporters.)

The Philippines is only one of several Asian producers that have markedly expanded shrimp exports in recent years. The growth of shrimp supplies has been partially balanced by growing demand for shrimp in the major import markets (Japan, the United States, and Europe). But there have also been substantial price fluctuations as the market adjusts to the rapidly expanding supplies. Individual shrimp producers, as a consequence, now have to be aware of trends in the world shrimp markets when they make production decisions. For producers in the Philippines, the most closely watched market is that of Japan.

A. The Japanese Market

About 80 percent of Philippine shrimp exports were sold to Japan in 1988, the latest year for which complete export data are available. The Philippines held roughly 7 percent of the huge Japanese shrimp import market in 1989, the same as in 1988 (fig. 6). Although the Philippine market share has remained stable, the Japanese import market has undergone dramatic changes in recent years, which could affect the level of future Philippine shrimp exports to Japan. The quantity of shrimp imported into Japan from all

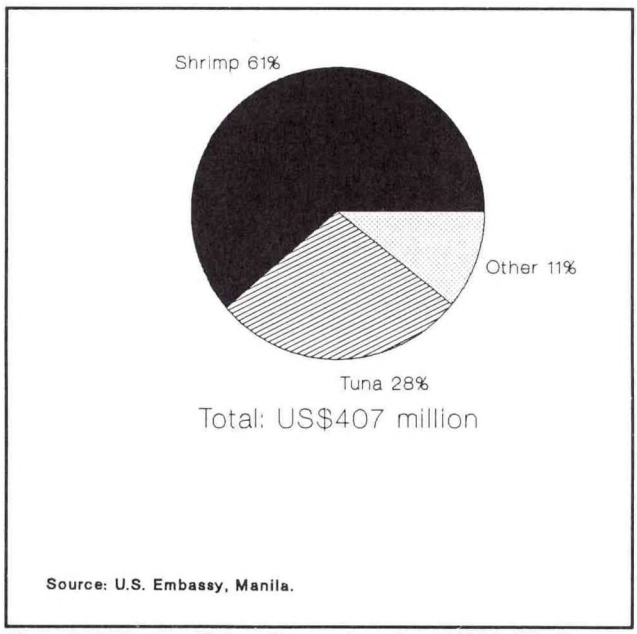


Figure 5. Philippines. Fishery Exports, by value, 1988.

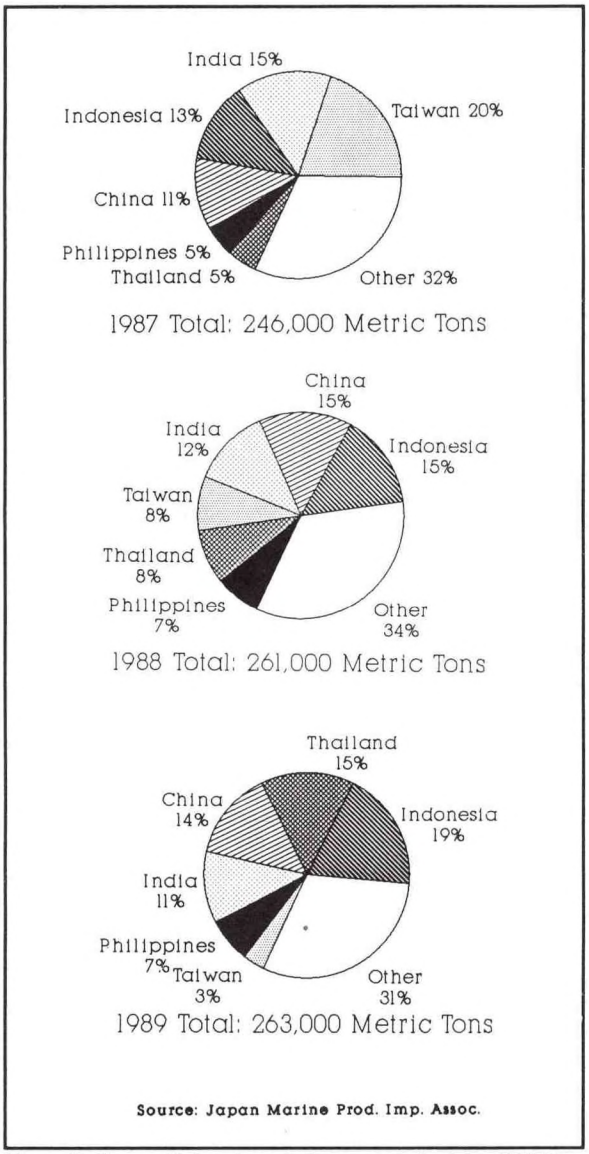


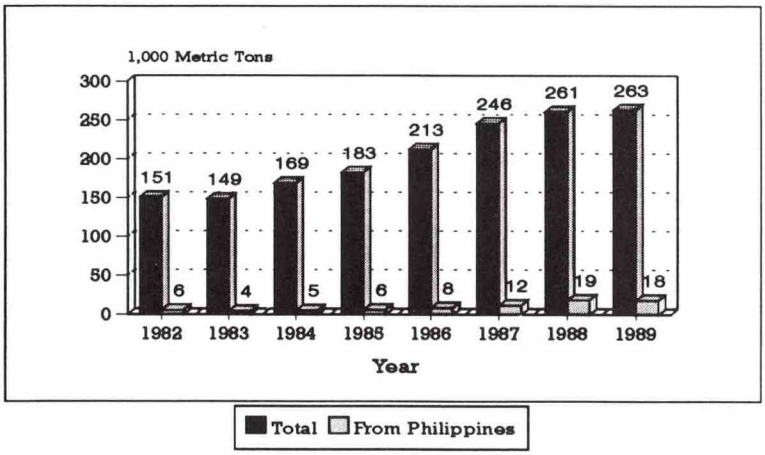
Figure 6.--Japan. Shrimp imports by country of origin, 1987-89.

suppliers has expanded only gradually from 246,000 t in 1987, to 263,000 t in 1989. But there have been important shifts in the countries supplying these imports. While Taiwan relinquished almost all of its future market share, because of widespread losses to disease in 1988 and 1989, Indonesia and Thailand increased exports of black tiger shrimp, becoming the largest suppliers to the Japanese market. Together with China, which produced an estimated 200,000 t of farmed white shrimp in 1989, Thailand and Indonesia supplied nearly half of Japanese shrimp imports.

Two important questions for Philippine shrimp farmers and investors are: 1) whether the supply of shrimp from other Asian countries will continue to increase, and 2) what effect such an increase may have on prices. The potential for a supply increase is clear. Asian shrimp production would have expanded more dramatically during the late 1980s if the region's pioneer producer, Taiwan, had not suffered a serious setback. Taiwanese shrimp production had increased from 33,000 t in 1985 to 75,000 t in 1987, but it fell to 45,000 t in 1988, and even lower in 1989. If farmers in Taiwan overcome the disease problems that plagued them in 1988-1989, Taiwanese production could again quickly increase. Similarly, China, which already is the world's largest producer of cultured shrimp, could continue to increase production levels by building shrimp farms in the warmer southern part of the country, where 2 crops per year could be harvested. Furthermore, Thailand and Indonesia each more than doubled their shrimp production between 1987 and 1989, and neither shows signs of having reached its production limits. (Recent reports, however, indicate that Indonesian shrimp farms are experiencing severe disease problems in 1990.) Other countries, such as Vietnam, Bangladesh, and Burma may also become significant shrimp suppliers.

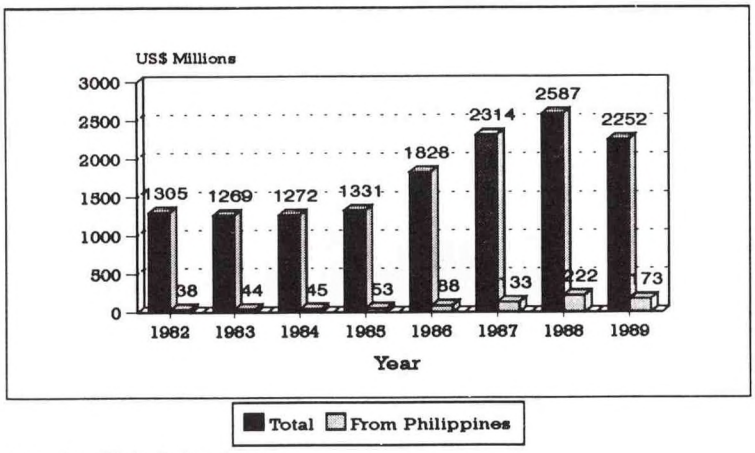
Although an annual farmed shrimp supply increase in Asia of 100,000 t during the next few years seems quite likely, the effect on prices is difficult to predict. The Asian shrimp producing countries export much of their output to Japan, where high incomes make shrimp widely affordable. The Japanese market demand is thus the principal factor determining regional shrimp prices. As Asian production of farmed shrimp increased in the 1980s, the Japanese demand for imported shrimp also increased (fig. 7). The quantity of shrimp imported by the Japanese traders increased by over 40 percent from 1982 to 1988, but in 1989 there were signs that the market demand may have leveled off. The quantity of the Japanese shrimp imports continued at the same level as in 1988, but the Japanese cold storage holdings of shrimp products reportedly reached almost 100,000 t, up from 60,000 tons in early 1987.[10] When wholesalers began selling off this buildup of shrimp inventories, (which partially resulted from the consumption slump that followed the Japanese Emperor's death in early 1989) prices decreased. As a result, the value of shrimp imports into Japan was considerably lower in 1989 than in 1988 (fig. 8), even though the quantity imported increased slightly.

For Philippine exporters, the softness of the Japanese market in 1989, and the growing competition from low-cost producers such as Indonesia and Thailand,[11] translated into lower average prices. Japanese wholesale prices for Philippine black tiger shrimp were about 20 percent lower than in 1988 (fig. 9). The lower prices meant



Source: Japan Marine Products Importers Association, Japan Tariff Association.

Figure 7.--Japan. Shrimp imports by quantity, 1982-89.



Source: Japan Marine Products Importers Association, Japan Tariff Association.

Figure 8.--Japan. Shrimp imports, by value, 1982-89.

that Philippine producers shipped almost the same amount of shrimp to Japan in 1989 (18,000 t) as in 1988 (19,000 t), but earned over 20 percent less in 1989 ($173 million versus US$222 million). The weak market was especially unwelcome in the Philippines because production increased significantly in 1989. The situation appears to have improved in 1990. Philippine producers were reportedly encouraged by strong Japanese market demand in early 1990. Japanese imports of shrimp from the Philippines reached 5,600 t by the end of April 1990, compared to 5,970 t during the same period in 1989.[12] Though the Japanese market was strong, there was growing concern in the Philippines about the heavy dependence on a single importer. Industry spokesmen called for diversification into other markets, such as that of the United States.

B. The U.S. Market

The U.S. market for imported shrimp has expanded along with that of Japan (fig. 10). U.S. imports doubled from 124,000 t in 1982 to 228,000 t in 1988. In 1989, the parallel development of the two large import markets continued. The U.S. import market showed signs of leveling off, as did Japan's. The most notable change in the U.S. market, in recent years, has been the rise of China as the largest supplier. As recently as 1986, China supplied only 9,400 t to the U.S. market; in 1989, it supplied almost 47,000 t, or about 20 percent of U.S. shrimp imports.

Philippine shrimp exports to the United States first exceeded 2,000 t in 1985, and expanded to 6,400 t in 1989, accounting for about three percent. The United States has become an important market for Philippine producers although shipments to the U.S. market were only about one-third of those exported to Japan. The Philippines has an advantage over some other Asian suppliers of fishery products because its exports to the United States have never

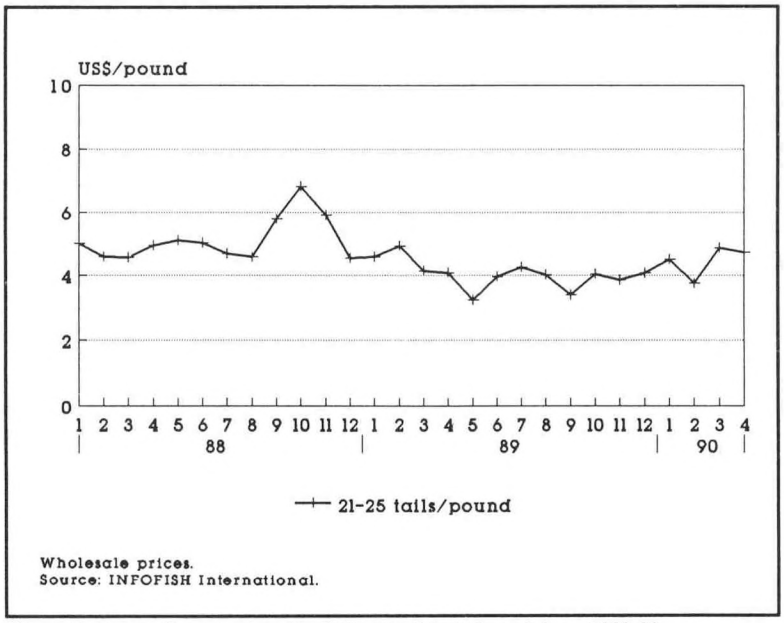


Figure 9.--Japan. Import prices for Philippine black tiger shrimp, 1988-90.

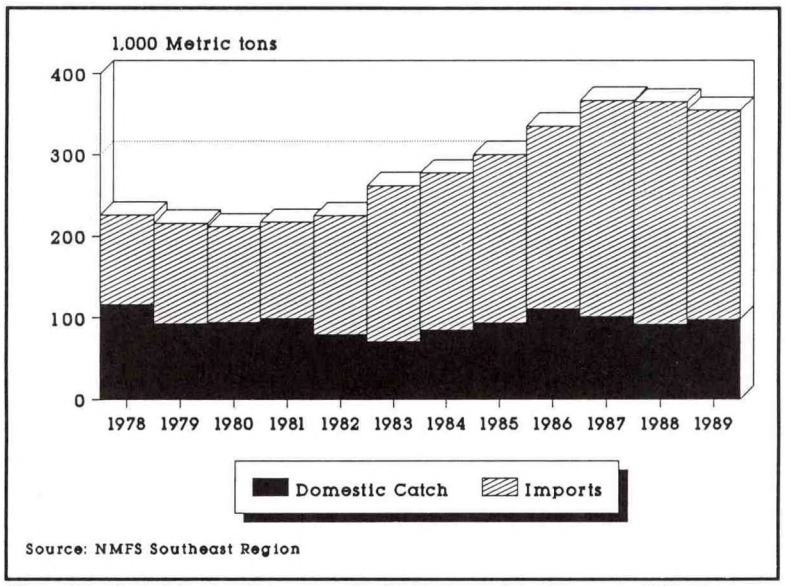


Figure 10.--United States. Shrimp supply: domestic catch and imports, 1978-89.

been "blocklisted" (slated for automatic detention and inspection because of suspected contamination). Even so, the growing presence of Philippine black tiger shrimp on the U.S. market comes as a surprise. Until quite recently, black tiger shrimp was not considered an acceptable substitute for white shrimp and other species familiar to the U.S. consumer. The advances that Philippine suppliers made in 1989 seem to have been a side effect of the worldwide price decrease that rattled the Philippine shrimp industry. According to several U.S. importers, the low prices for black tiger shrimp in 1989 (fig. 11), convinced reluctant importers and restauranteurs to try the unfamiliar shrimp species--with favorable results. The increasing acceptance of black tiger shrimp may mean that Philippine exports to the U.S. market will continue to expand, even if black tiger prices rise. As of mid-1990, however, the low production levels reported for the Philippines appeared to be reflected in U.S. import statistics. Philippine suppliers shipped only 1,890 t of shrimp to the United States between January and May 1990, compared to 2,170 t during the same period in 1989.

A factor that may allow Philippine suppliers to increase shrimp sales to the United States, assuming production levels continue to rise in the Philippines, is U.S. legislation concerning shrimp fishing. Current U.S. law specifies that, after May 1991, shrimp will not be imported from countries that endanger sea turtles through their shrimp fishing practices. Such embargoes on traditional U.S. suppliers (Mexico and other Caribbean and Latin American states) would probably result in more imports from Asian shrimp producers. Many affected countries, however, reportedly plan to comply with the terms of the legislation, which calls for use of "turtle excluder devices" (TEDs) in areas where sea turtles are found.

C. The European Market

The European Community (EC) shrimp import market reached 270,000 t in 1988, roughly the size of the Japanese and U.S. markets. However, about one-third of EC imports originate in other EC countries (80,000 t in 1988). The prospects for Asian shrimp exports to the EC are favorable because shrimp fisheries in European waters appear to have peaked during the 1980s. For example, Norway exported over 10,000 t of wild shrimp per year to the EC between 1983 and 1985, but its exports fell to under 5,000 t by 1987. Meanwhile, cultured shrimp imports from China (white shrimp) and Indonesia (black tiger shrimp) have increased each year. Black tiger shrimp is reportedly gaining wide acceptance in the EC markets of France, Spain, and the United Kingdom.[13]

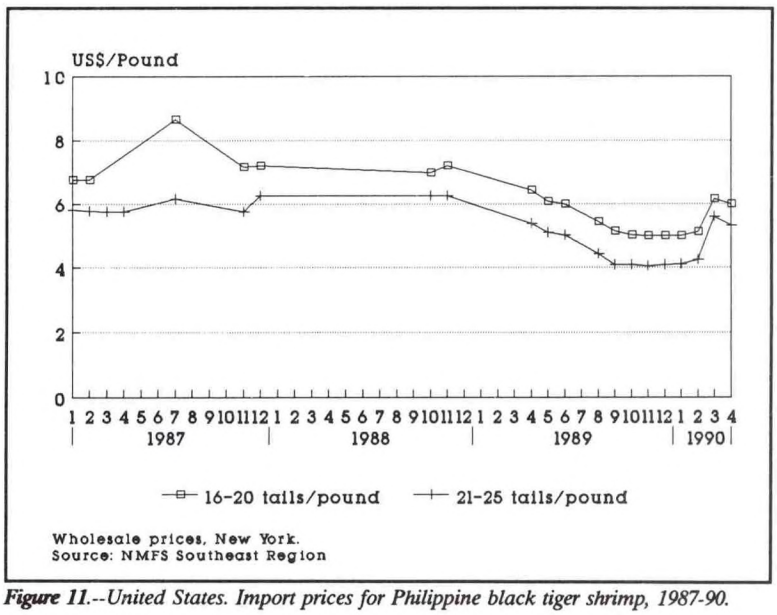


Figure 11.--United States. Import prices for Philippine black tiger shrimp, 1987-90.

There are few reports of Philippine shrimp exports directly to European countries. In 1989, however, a Singapore company, Hock Bee Frozen Foods, gained a contract to supply processed shrimp products to the UK-based Fathom Seafood for distribution throughout Europe, where processed fishery products are rapidly gaining popularity. The company planned to obtain shrimp from the Philippines, as well as from China, Indonesia, Thailand, and Malaysia. In addition, a Manila newspaper reported in 1990 that the Philippine Department of Agriculture was working on a countertrade scheme whereby shrimp would be shipped to Italy in exchange for Italian trainer aircraft.

This report was originally prepared by Brian McFeeters and published as IFR 90/61 on August 31, 1990.

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1. A hectare is 10,000 square meters, or about 2.5 acres.

2. Jochen H. Nierentz, "Product Explosion and Market Reaction to Asia's Black Tigers and China Whites," *Quick Frozen Foods International*, April 1990.

3. Aquatic Farms Limited, "Annex 6, Philippines Country Brief," *Asia-Wide Shrimp Agro-Industry Sector Study*, (Washington: the World Bank, 1989), p. 227.

4. SEAFDEC is an international organization established in 1966 to promote fishery production in Southeast Asia. The members are Japan, Malaysia, the Philippines, Singapore, and Thailand.

5. Aquatic Farms Limited, p. 230.

6. "Evils of Prawn Farming Cited," SEAFDEC Newsletter, Vol. 11, No. 3, 1988, p. 6.

7. According to the U.S. Embassy in Manila, Cable dated February 7, 1989.

8. This section relies on a report by Philip S. Cruz, Most Aquaculture Marketing Corporation, Bacolod City, Negros Island, cited in *World Shrimp Farming*, July 1990, pp. 2-4.

9. *Aquaculture Digest*, September 1990.

10. *Infofish International*, 4/1990, p. 36.

11. Exact production costs for different countries were not available as this report was being prepared, but some costs, such as labor, are clearly lower in Indonesia and Thailand than in the Philippines.

12. *Infofish Trade News*, April 30, 1990.

13. For detailed information on the EC market, see Helga Josupeit, *The European Shrimp Market - Coldwater versus Warmwater*, FAO-Globefish, Rome, 1989.

APPENDICES

Appendix 1--Philippines. Shrimp* Production, by quantity, 1980-89.

Year	Production		
	Wild	Aquaculture	Total
	1,000 Metric Tons		
1980	25	2	27
1981	37	4	41
1982	44	5	49
1983	39	13	52
1984	39	26	65
1985	52	27	79
1986	63	28	91
1987	44	35	79
1988	46	34	80
1989	--	50**	--

* Excluding freshwater prawns.
** Preliminary estimate.
Source: FAO, Yearbook of Fishery Statistics, various years, and FAO/Globefish database.

Appendix 2--Philippines. Shrimp Exports, by quantity and value, 1983-1988.

Year	Exports	
	Quantity	Value
	1,000 Metric Tons	US$ Millions
1983	5	36.7
1984	7	35.4
1985	9	63.6
1986	12	105.8
1987	16	156.0
1988	24	251.8

Source: Philippine National Census Statistics, as cited in Aquatic Farms Ltd., Asia-Wide Shrimp Agro-Industry Study, 1989.

3.6

TAIWAN

The future of Taiwan's shrimp culture industry is uncertain. Originally a by-product of the more profitable milkfish culture industry, shrimp monoculture in Taiwan experienced its first period of rapid growth in the 1980s, with harvests growing over 1200 percent between 1981 and 1987. Key to this explosive growth in the shrimp culture industry was the development of the black tiger shrimp (*Penaeus monodon*) into a commercially profitable species for intensive aquaculture. Acceptance of the *P. monodon* in the Japanese and U.S. market also served as an incentive to shrimp farmers. Exports of *P. monodon* to Japan and the United States climbed dramatically from 1977 to 1987, and Taiwan became the leading producer of cultured shrimp in Asia in the last two years of this period. These advances, however, were short-lived. Since 1988, much of Taiwan's *P. monodon* industry has been wiped out by a combination of poor farming practices, polluted water, and the spread of monodon baculovirus (MBV), a virus which decimated entire crops of *P. monodon* in the larval and juvenile stages of growth in 1988 and 1989. Although Taiwan's shrimp farmers are struggling to regain lost ground, the continued presence of MBV, high production costs, and the increased competitiveness of other shrimp-producing nations would seem to make Taiwan's reemergence as a leading shrimp producer unlikely.

CONTENTS

I. BACKGROUND

Aquaculture has a long history in Taiwan (figure 1), but the intensive cultivation of shrimp is a relatively recent phenomenon. For centuries, fish farmers in Taiwan captured juvenile *P. monodon* from coastal waters, stocked them in milkfish ponds and harvested them as an extra crop. Intensive monoculture of *P. monodon* evolved with the emergence of three crucial developments in the aquaculture industry.

Penaeus monodon: Shrimp culture rose rapidly to a position of major importance in Taiwan's aquaculture industry in the period from 1977 to 1987. Foremost among the reasons for this rapid development of the shrimp industry was the successful artificial propagation of *P. monodon*, a species large enough to be commercially profitable and hardy enough to withstand a broad range of water conditions. Dr. I-Chiu Liao, the acknowledged "father" of Taiwan's *P. monodon* farming industry and Director General of Taiwan's Fisheries Research Institute, describes the species as a "super shrimp" - ideal for intensive aquaculture operations (photo 1). The *P. monodon*, under optimum conditions, can grow to 30 grams in just 14 weeks, reaching a marketable size faster than any other cultured penaeids; it can tolerate a wide range of salinities and survive temperatures as low as 12° C and as high as 36° C. *P. monodon* is also well suited to intensive farming, and can achieve a survival rate of approximately 80 percent even when stocked as high as 400,000 shrimp per hectare.

***Figure 1.**--Map of Taiwan.*

Photo 1.--Taiwan. Tungkang Marine Laboratory, Pingtung, Taiwan. ©Henry R. Branstetter

Feedcosts are also lower than for many other species of shrimp because *P. monodon* requires only 35 percent protein and has a feed conversion ratio of 1.6 to 1.

Feeds: A second development instrumental to the shrimp culture "boom" of the 1980s was the introduction of artificial feeds specifically designed for the *P. monodon*. Dr. Liao, in addition to his research on P. monodon propagation, was also deeply involved in the development of these artificial feeds. The low average cost of domestically produced pellet feeds (about $1 per kilogram) greatly aided the profitability of P. monodon aquaculture and contributed to the sudden rise in production. After the introduction of artificial feeds in the mid-1970's, Taiwan's shrimp production soared from less than 100 t in 1975 to 18,000 t in 1985, and then to a peak of 95,000 t in 1987 (appendix A, figure 2). The domestic production of shrimp feeds mirrored this rise, climbing from 110 t annual production in 1977 to over 100,000 t by 1986 (appendix B). The pond area devoted to shrimp cultivation also showed a dramatic change, rising from 3,500 ha in 1981, to a highpoint of 17,500 ha in 1988 (appendix C).

Hatcheries: A third factor that paved the way for large-scale *P. monodon* culture in Taiwan was the establishment of private hatcheries. Juvenile *P. monodon* normally hide among weeds and grass in estuarine waters of low salinity. In the past, fishermen placed bundles of grass in estuaries to attract seed, then scooped them up with dipnets. Until the first success in artificial propagation of *P. monodon* in 1968, all shrimp seed for aquaculture in Taiwan were of wild origin. The unpredictability and quantitative limitation of the seed supply severely hindered development of shrimp culture on the island.

In 1988 there were approximately 2,000 shrimp hatcheries and nurseries in Taiwan, which produced more than 4 billion *P. monodon* shrimp larvae. There is no longer a shrimp seed collecting industry on the island. With hatcheries and nurseries working at maximum capacity, heavy competition kept the price of shrimp seed relatively low. Several times during the 1980s, seed production actually exceeded demand, and the seed price dropped below the cost of production. Fearing the repetition of such an event, hatchery operators met in January, 1988, and agreed on a short-lived moratorium which temporarily stopped the import of brooders.

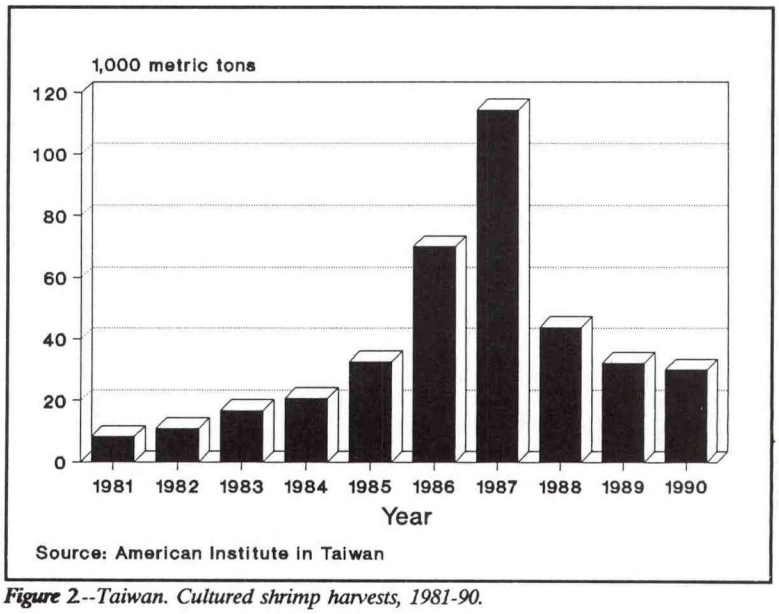

Figure 2--Taiwan. Cultured shrimp harvests, 1981-90.

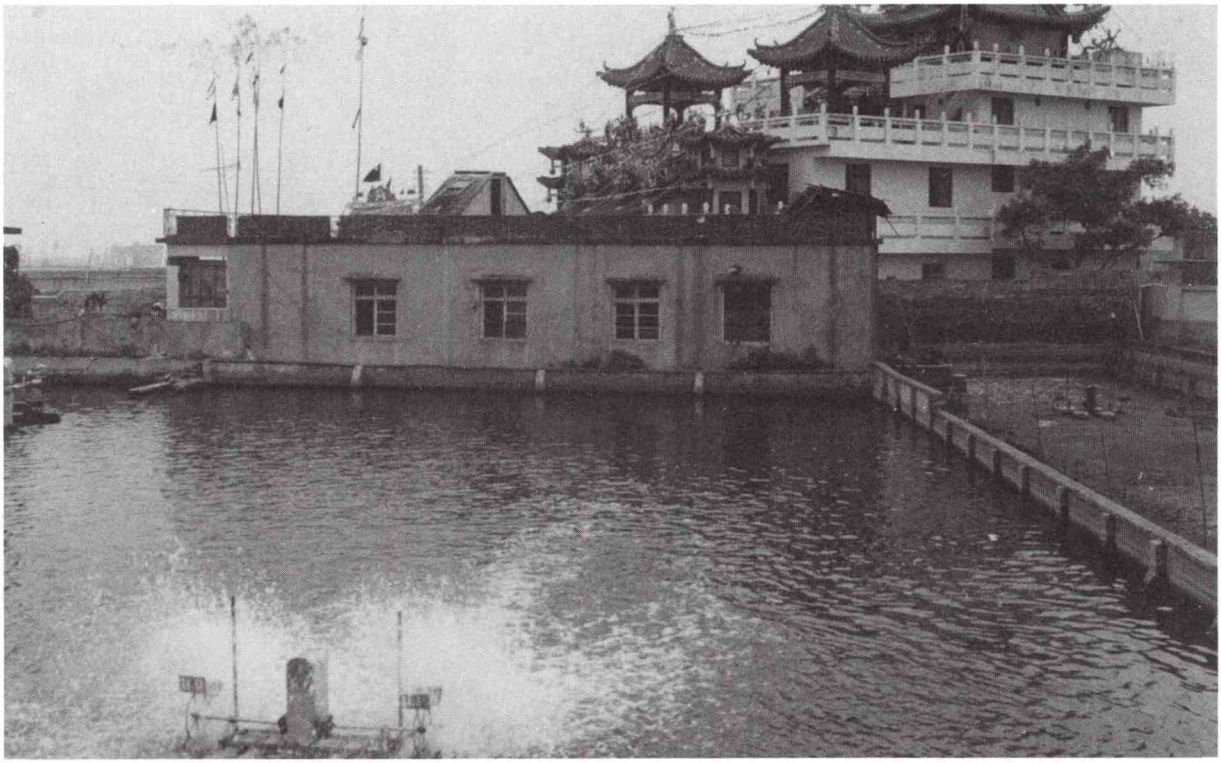

Photo 2--Taiwan. Intensive shrimp farm. ©William D. Chauvin.

II. HARVESTS

The Boom: The rapid growth of Taiwan's shrimp culture industry during the 1980s was truly remarkable. The annual harvest grew from a mere 8,300 t in 1980 to over 114,000 t in 1987 - an average growth rate of nearly 60 percent per year (photo 2). Because of the high profit potential involved in the culture of *P. monodon* (up to $30,000 per ha), many farmers rushed into small-scale intensive culture operations without fully understanding the technology and methods required to ensure a stable and productive grow-out environment.

The Crash: Although the shrimp culture industry boomed through the early and mid-1980s, its success was short-lived. In 1988, disease spread rapidly through Taiwanese shrimp ponds when the first spring crop began growing. While several farms suffered crop failures in 1987, few farmers were concerned, and expectations for continued expansion in 1988 remained high. By the following spring, however, *P. monodon* farms throughout the island reported that the larvae were dying a few weeks after being placed in the grow-out ponds. As the season continued, it became clear that few, if any, ponds would remain untouched by the effects of a yet unknown plague. Taiwan's shrimp harvest for 1988 was only 43,700 t - a decrease of 60 percent from the 1987 harvest of 114,500 tons. This trend continued in 1989, as the shrimp culture industry was able to produce only 32,300 tons.

The causes of the crash are complex, and many of the variables involved have yet to be identified. Much of the problem, however, lay in short-sighted farming practices. The origins of the "epidemic" included the use of temperatures as high as 35° C in order to speed growth (32° C is the recommended maximum); overstocking; poor-quality artificial feed; misuse of antibiotics; and lack of sanitation and control against water pollution (many ponds were pumping in waste water from neighboring ponds due to crowded conditions) (photo 3). In this environment that bacteria, as well as the virus Monodon baculovirus (MBV), spread rapidly through the ponds.

The Recovery: In 1990, the shrimp culture industry showed its first signs of recovery. Up until 1988, *P. monodon* was the undisputed leader in the Taiwanese shrimp culture industry. With the outbreak of MBV,

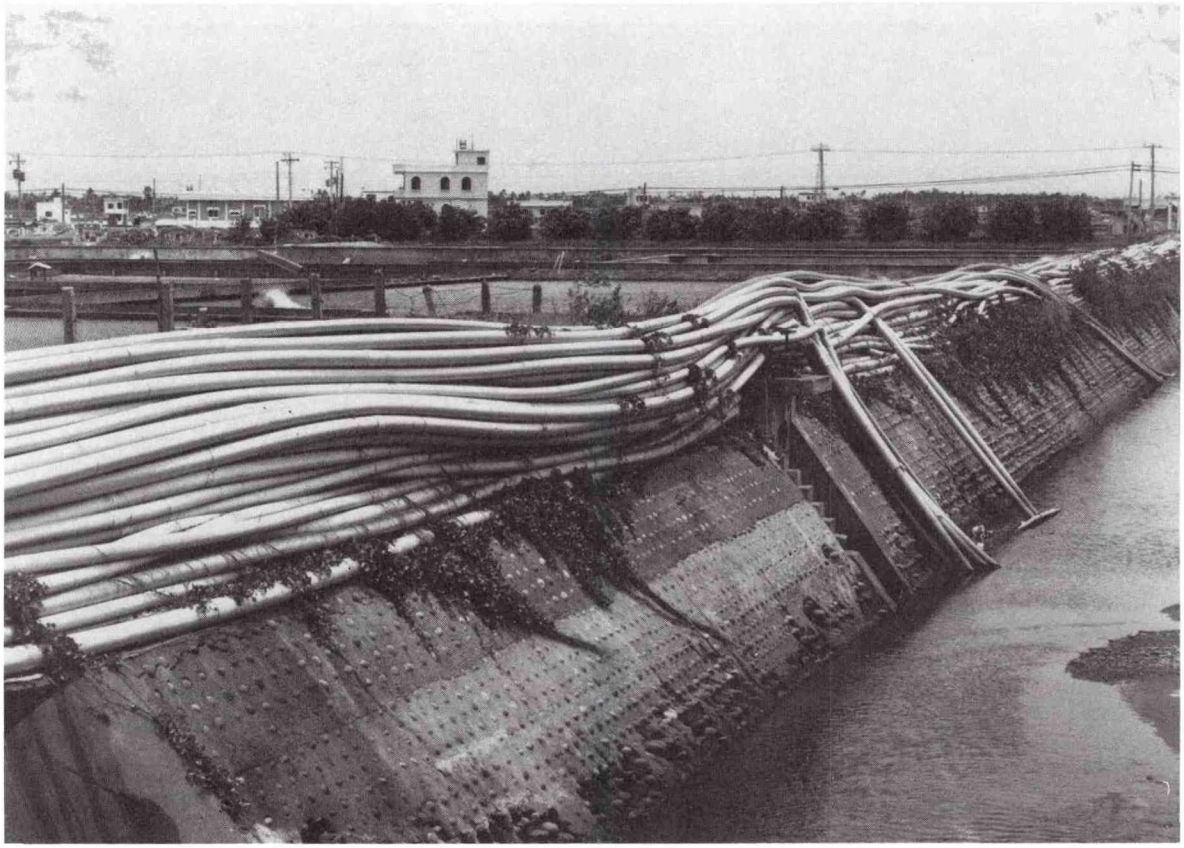

Photo 3.--Taiwan. Supply lines from ocean to ponds. ©James W. Avault

however, farmers have lowered black-tiger stocking densities and switched to other commercially viable species which are resistant to the virus. To accommodate the culture of these new species in a cleaner environment, the concentration of farms in the southwest of Taiwan has broken up as farms begin to relocate in the northwest and northeast of the island.

Most notable among the substitute species are red-tail shrimp (*Penaeus pencillatus*), the China white shrimp (*Penaeus chinensis*) and kuruma shrimp (*Penaeus japonicus*). Of special significance is the kuruma shrimp, which constituted nearly 25 percent of the 1990 shrimp culture harvest, and has great potential as an export to Japan. In addition to being MBV-resistant, *P. japonicus* is a popular species with Taiwanese farmers for the following reasons: it can be farmed at a lower water temperature than P. monodon, and thus saves on energy costs; it commands a very high price in Japanese markets because of its use in sushi; larval-rearing techniques are well documented; *P. japonicus* can be transported live over long distances. Most of the *P. japonicus* farms are on the central-west and northeast coasts.

III. EXPORT MARKETS

Japan: Japan is Taiwan's largest fisheries export market, accounting for 60 to 70 percent of Taiwan's total fishery exports in recent years. Shrimp, particularly *P. monodon*, is one of the chief fishery exports to Japan. Key to the growth of shrimp exports to Japan was the gradual acceptance of Penaeus monodon, by the Japanese consumer. Once a reputation for quality had been established in the Japanese market, exports of Taiwanese shrimp skyrocketed, with the P. monodon leading the way (appendix D, figure 3). Between 1981 and 1987, exports of shrimp to Japan increased from 8,000 t ($48 million) to nearly 50,000 t ($509 million)- an increase of 525 percent by quantity or 960 percent by value. By 1986, Taiwan had become the leading supplier of shrimp to Japan, holding a market share of approximately 19 percent. In 1987, Taiwan was able to increase its share of the Japanese shrimp import market to 22 percent -- far outstripping competitors such as China, Indonesia, Thailand, and India (figure 4).

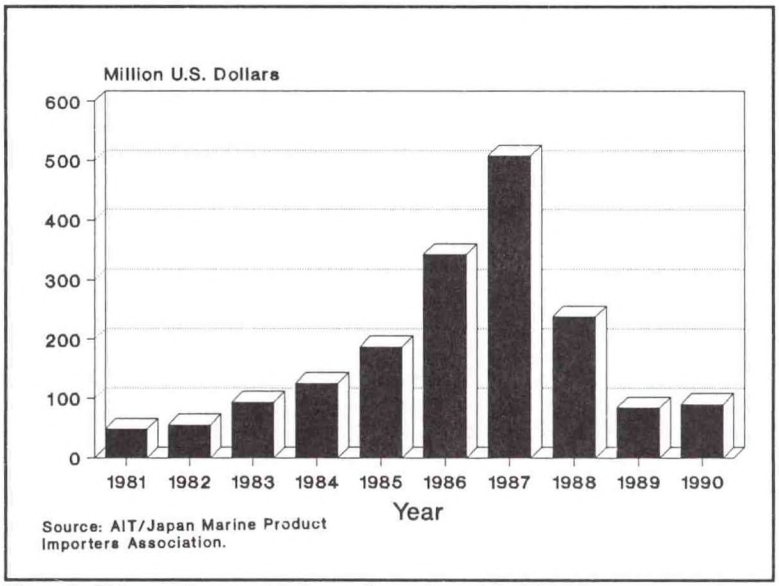

Figure 3.--Taiwan. Exports of shrimp to Japan, by value, 1981-90.

Taiwan's brief role as Japan's leading supplier of shrimp ended in 1988. In the space of one year, Taiwan dropped from being Japan's leading supplier of shrimp to fifth place, measured by value of exports, behind Indonesia, China, Thailand, and India. The quantity of shrimp exported to Japan in 1988 was 22,000 t, a drop of over 55 percent from 1987 and a decrease in market share from 22 percent to 9 percent. This downward trend continued into 1989, with Taiwanese exports of shrimp to Japan dropping nearly 60 percent from 22,000 t in 1988 to about 9,000 t in 1989. Measured in terms of value, Taiwan's share of the Japanese shrimp import market in 1989 was a mere 4 percent (figure 4). Although Taiwan's shrimp exports to Japan would improve slightly in terms of quantity in 1990 at 90,000 t, the market share remained unchanged.

The United States: The United States is Taiwan's second largest fisheries export market, usually accounting for about 20 percent of Taiwan's total fishery exports. Along with tuna, shrimp is one of Taiwan's principal fishery export items to the United States. Mirroring the rise in production, the level of shrimp exports to the United States climbed dramatically during the 1980s. Between 1981 and 1987, exports of P. monodon and other species of shrimp to the United States grew from 2,500 t ($11 million) to nearly 17,000 t ($160 million), an increase of 580 percent by quantity or 1,350 percent by value. In 1987, the peak of the shrimp trade with the United States, Taiwanese shrimp accounted for nearly 28 percent, by value, of Asian shrimp exports to the United States, and over 9 percent of global exports of shrimp to the U.S. market.

Exports to the United States crashed along with overall production levels in 1988. Shrimp exports to the U.S. in 1988 were only 8,000 t ($85 million), a decrease of over 50 percent by quantity or 47 percent

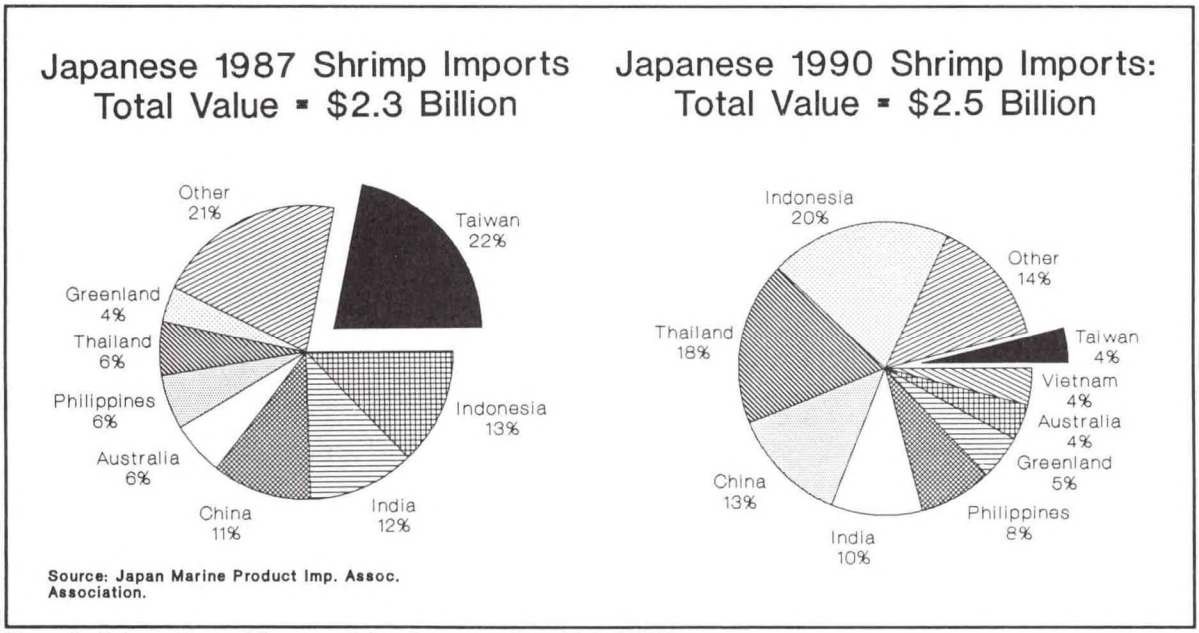

Figure 4.--Taiwan. Share of Japanese shrimp import market, 1987 vs. 1990.

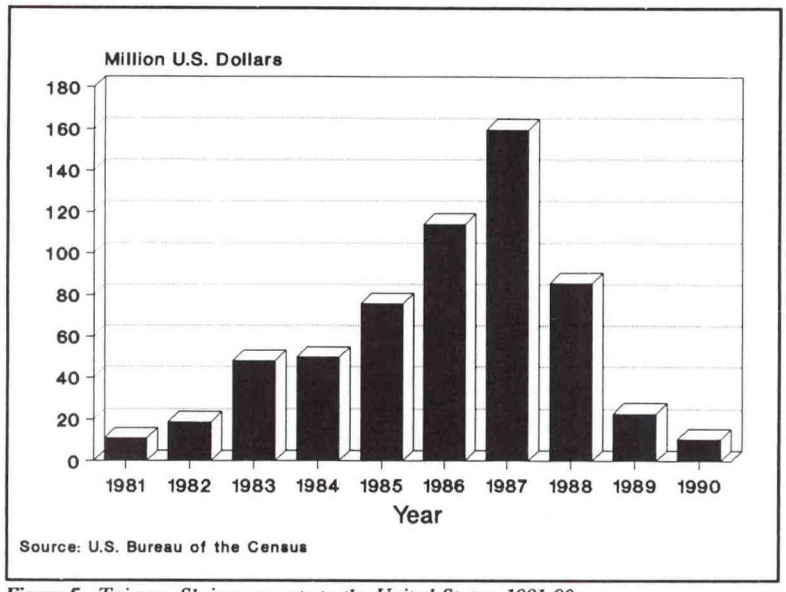

Figure 5.--Taiwan. Shrimp exports to the United States, 1981-90.

by value. Despite a minor recovery in production levels, Taiwan's exports of shrimp to the United States continue to decline since the initial crash of 1988. Export levels dropped by nearly 60 percent in 1989 to roughly 3,400 t, and by a further 50 percent in 1990 to only 1,600 tons (appendix E, figure 5). Taiwan occupied only 0.7 percent of the U.S. shrimp import market in 1990 -- a precipitous drop from its 1987 market share of 7 percent.

IV. OUTLOOK

It is unlikely that Taiwan will be able to regain its position as a world leader in the shrimp industry in the near future. Although Taiwanese researchers have made significant progress with the problem of MBV contamination, there is no immediate cure for problems such as overcrowding, pollution, and short-sighted farming practices. As long as this is the case, intensive culture of Penaeus monodon, the species which was the engine of growth for Taiwan's shrimp culture industry, is unlikely to return to levels seen in the 1980s. More importantly, due to the spread of advanced shrimp culture technology and methods to other countries in Asia, Taiwan now faces far tougher competition than in previous years. Compared to countries such as Thailand, China, Indonesia and the Philippines, shrimp production costs in Taiwan are quite high. These differences in production costs will serve as a formidable barrier to Taiwan again becoming an effective competitor in international shrimp markets.

Many observers of Taiwanese shrimp culture claim that the industry is not dead, but is simply changing gears. In the face of a shrimp culture boom in other Asian countries, Taiwan's most important role may be to promote shrimp farming in other countries by serving as a source for research and development capital, and as a partner in joint ventures. Many of Taiwan's largest shrimp producers have already set up operations in other Southeast Asian countries. The Philippines has been the most popular site so far, followed by Indonesia, Thailand, the Dominican Republic, Panama and Ecuador. Projects have included the establishment or financing of hatcheries, shrimp farms, processing centers and shrimp feed plants. Taiwan has the technical expertise to help developing nations expand capacity, improve quality, and win acceptance into the Japanese market. Even the United States has benefitted from Taiwanese expansion overseas. Chung Mei Shrimp Farms, a Taiwanese venture recently developed a 1,300 acre shrimp farm near Arroyo City in Texas.

Another possible connection between Taiwan and shrimp producers in developing countries is in the field of reprocessing. Although Taiwan's shrimp farmers have successfully banned imports of shrimp for re-processing and export, it is possible that Taiwan will eventually allow imports of raw material and will export higher-value items such as cooked and peeled shrimp tails. Taiwan is also expected to increase investment in processing facilities overseas.

This report was originally prepared by David Decker and Todd Schneider and published as IFR 91/66 on August 16, 1991.

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APPENDICES

Appendix A.--Taiwan. Cultured shrimp harvests by species, 1981-90.

Year	Species				Total
	P. monodon	P. japonicus	P. pencillatus	Others	
	--Metric tons--				
1981	6,000	100	-	2,200	8,300
1982	8,000	50	-	2,900	10,950
1983	15,000	50	-	1,750	16,800
1984	18,000	200	-	2,500	20,700
1985	30,000	500	-	2,200	32,700
1986	60,000	800	3,000	5,200	70,000
1987	95,000	1,500	7,000	11,000	114,500
1988	30,000	4,000	3,500	6,200	43,700
1989	16,700	5,800	750	9,050	32,300
1990	NA	NA	NA	NA	35,000*

*Estimated figure.
Sources: American Institute in Taiwan; Asian Fisheries Society, **Aquaculture in Asia**, 1990.

Appendix B.--Taiwan. Shrimp feed; number of manufacturers and annual production, 1977-86.

Year	Number of Manufacturers	Annual Production
		--Metric tons--
1977	3	110
1978	3	820
1979	4	3,600
1980	5	6,400
1981	7	9,000
1982	12	16,000
1983	20	30,000
1984	30	36,000
1985	40	51,000
1986	50	100,000

Source: Republic of China, Council of Agriculture, **Shrimp Farming and Exports in the R.O.C.**, 1987.

Appendix C.--Taiwan. Area in use for aquaculture and shrimp culture, 1981-89.

	Shrimp Culture	Total Aquaculture	Percentage
	-- Hectares --		
1981	3,528	60,829	6%
1982	NA	NA	NA
1983	4,051	67,051	6%
1984	4,489	66,820	7%
1985	4,500	65,980	7%
1986	9,350	65,047	14%
1987	15,706	66,302	24%
1988	17,460	67,061	26%
1989	15,944	71,083	22%

Source: American Institute in Taiwan, 1991.

Appendix D.-- Taiwan. Exports of shrimp to Japan, by volume and value, 1981-90.

Year	Volume	Value
	--Metric tons--	--US$ Millions--
1981	7,774	48.5
1982	7,759	56.1
1983	11,052	94.0
1984	16,494	125.8
1985	21,770	187.4
1986	37,824	342.8
1987	49,229	508.7
1988	21,986	238.5
1989	8,925	84.9
1990	10,492	90.4

Source: Japan Marine Products Importers Association, 1981-90.

Appendix E.-- Taiwan. Exports of shrimp to the United States, by volume and value, 1981-90.

Year	Volume	Value
	--Metric tons--	--US$ Millions--
1981	2,504	10.9
1982	4,225	18.7
1983	9,030	48.1
1984	8,297	49.9
1985	13,420	75.7
1986	15,691	114.1
1987	16,806	159.6
1988	7,877	85.6
1989	3,369	23.0
1990	1,593	10.7

Source: U.S. Bureau of the Census, 1981-90.

3.7

THAILAND

Thailand's tiger shrimp (*Penaeus monodon*) aquaculture industry along the coast of Songkhla and Nakhon Si Thammarat Provinces (figure 1) continues to grow explosively. Pond areas have tripled from 1,600 to 4,800 hectares (ha). Prices have doubled from $4 to nearly $8 per kilogram (kg) because of severe shortfalls in production in central and eastern provinces afflicted by disease and pollution. The proliferation of "wildcat" ponds operated by small-time farmers is causing similar problems in the south. Reckless overstocking and poor drainage have already caused losses in the Pakpanang and Hua Sai districts of Nakhon Si Thammarat. The culture of marine shrimp is a relatively new field which will require considerable research to control disease and conserve the environment. Recognizing the need to establish baseline data and answer environmental questions, academics and private firms have begun the necessary research. The governor of Songkhla Province, in consultation with the two largest shrimp culture companies, has drafted regulations to combat the spread of pollution and disease. Nakhon Si Thammarat Province is also expected to issue similar regulations in 1991, but enforcement will be difficult in both provinces.

CONTENTS

I. BACKGROUND

Thailand's shrimp culture industry is the fastest growing in Southeast Asia. In only 5 years, Thailand has outstripped its competitors to become the region's number one producer. Thai shrimp harvests in 1988 reached 55,000 metric tons (t), a 320 percent increase over the 13,000 t produced in 1984.[1] Indonesian and Philippine harvests rose by only 62 percent and 51 percent, respectively, over the same time period. Thailand's 1989 farmed shrimp production nearly doubled the 1988 level, surpassing 100,000 tons (table 1). As happened in Taiwan a few years earlier, however, diseases in Thailand's central provinces have caused the country's total production for 1990 to stagnate at the 1989 level of 100,000 t (although some sources estimate an increase this year of 20,000 t).

Thailand's rapid development of a commercial shrimp culture industry appears all the more remarkable given its late start. Thai farmers have long been adept at using traditional extensive shrimp farming methods. Semi-intensive shrimp cultivation, a comparatively recent phenomenon, involves raising hatchery-produced postlarvae (pl) on commercial feeds in grow-out ponds. This system yields from 3,100-6,300 kilograms/ha per year. However, the system demands a measure of sophistication in pl and feed production and in pond management. Thailand's tiger shrimp industry has changed dramatically during 1990 as prices have doubled to nearly $8 per kilo (at an exchange rate of 25 baht equals one dollar). A

Figure 1. *Map of Thailand.*

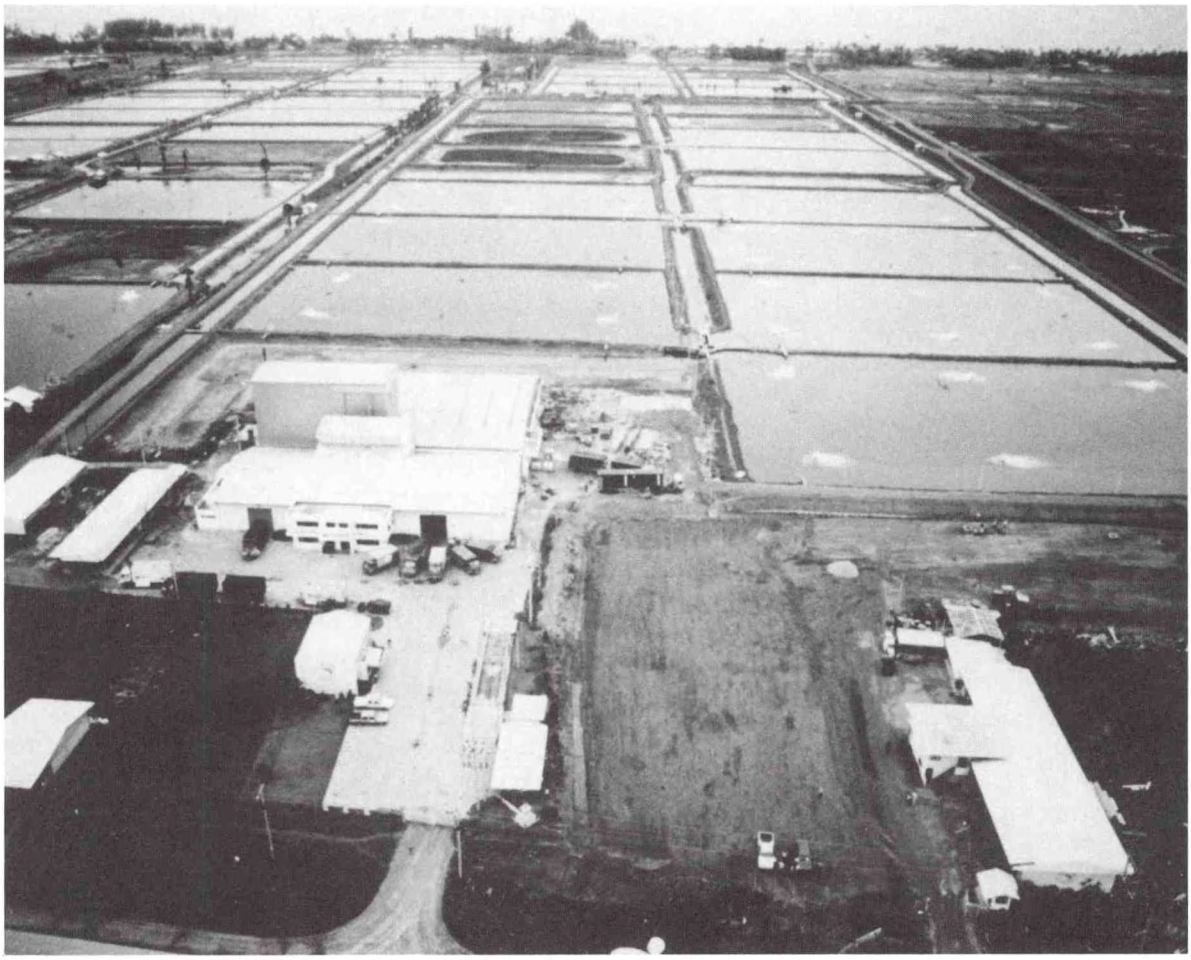

Photo 1.--Aquastar shrimp farming facilities, Songkhla. ©Aquastar Ltd.

major factor has been the sudden collapse of shrimp aquaculture in Samut Sakhon and other central coastal provinces. Overstocking and poor drainage spread viral disease which devastated the 1990 crop. The central provinces which formerly produced 70 percent of total Thai shrimp harvests, now account for no more than 10 percent. Eastern provinces, such as Chantaburi, have been similarly afflicted and as a result the south's share of shrimp production has skyrocketed in one year from 10 to 50-60 percent. Processing plants in the central region, suddenly bereft of supply and faced with fixed running costs and overseas contracts, are offering premium prices for southern produce.

Thailand's 1990 high prices parallel worldwide market trends. While the world market for shrimp continues to expand, both Indonesia and the Philippines have been slow to recover from the 1989 price slump, when many investors deserted the industry. In both countries, the 1990 harvest is expected to be no higher than that of 1989.[2]

Table 1. Southeast Asia -- Production of Cultured Shrimp, 1984-89.

Country	Year					
	1984	1985	1986	1987	1988	1989
	-- 1,000 Metric Tons --					
Thailand	13	16	18	25	55	100
Indonesia	32	37	41	45	52	100
Philippines	29	29	31	33	42	40

Source: U.S. Consulate, Songkhla, November 1990.

Aquastar and Charoen Pokphand (CP) are the largest firms in the southern shrimp aquaculture industry. Both are vertically integrated enterprises which produce tiger prawns from eggs through nursery larvae to adult shrimp in grow-out ponds. Vertical integration kept operating costs significantly lower than the $3.80/kg prices of late 1989 (which many believed would drive out small independent growers whose operating costs were much higher). The low cost structure enabled both Aquastar and CP to prosper when 1990 prices rose to $8 per kilogram.

II. AQUASTAR

Aquastar, a Thai company with American shareholders, bought 38 ha of coastal rice paddy in 1985. The site of the company's purchase is located in Songkhla's Kanod District and it was seen as a novel bid to expand the cultivation of prawns beyond traditional estuary and mangrove regions to coastal paddy land. After successful harvests from demonstration ponds, Aquastar negotiated with 293 landowners in seven locations to convert their paddy fields into 310 shrimp ponds (1 ha each), with financing provided by the Bank of Thailand. Constructed on a uniform design, the ponds were equipped with aeration floats, salt-water intake and discharge canals, and stocked with pl from Aquastar's hatchery and supplied by feed produced at an Aquastar mill. Aquastar provided training and follow-up extension services, maintaining stocking density at 25 pl per square meter. Reared in seawater, the shrimp were ready for harvest within 4 months. By October 1989, two of the seven groups had completed their first harvests. The shrimp were processed and frozen at a rented packing plant on the Songkhla-Hat Yai road for later truck transport to Bangkok and export to Japan.

During 1990, Aquastar moved into a new location with 41 new ponds covering 40 hectares. Sixteen of these will be stocked in January 1991. The Bechtel Corporation of the United States is supervising construction of the remaining ponds, which comprise part of Aquastar's ambitious expansion plan for 500-600 ponds in 50-pond clusters. Aquastar's feed mill has doubled its capacity to 2,000 t daily, but its cold store and processing plant, originally planned for completion in January 1990, will not be fully operational until March 1991. Frozen prawns are still trucked to Bangkok for export. Utilization of Songkhla port, a factor in selection of this site, will begin once the plant (capacity: 60 t per day) comes on line.

The individual owner-operators of Aquastar's grow-out ponds have been the primary beneficiaries of the high 1990 prices. With excellent food-conversion ratios and rapid growth rates, harvests have averaged 5-6 t per 1 ha pond, with some well-maintained ponds averaging 7-9 tons. Owners are now expected to repay loans after four harvests (two per year) rather than the seven originally projected.

The company's international marketing position has improved considerably since 1989. The Trouw division of British Petroleum, which in mid-1988 acquired 10 percent of Aquastar's stock, is responsible for promoting seafood in the American market and has succeeded handsomely. Japan is the principal market, and about half of the company's exports are marketed there. Aquastar entered the market in 1990, and the United States now amounts to 15 percent of Aquastar's exports. The company is currently concentrating its marketing strategy on Europe, planning to raise its 5 percent share to 15 percent in 1991.

III. CHAROEN POKPHAND

The Charoen Pokphand group (CP) initiated shrimp culture operations in 1988, purchasing large tracts of paddy land in Hua Sai (Nakhon Si Thammarat Province) and converting them into ponds. CP, a Bangkok agro-industrial conglomerate, is the world's fifth largest producer of animal feed and has a wide range of interests in Southeast Asia, Hong Kong, Taiwan, China and the United States.

CP began the construction of two projects in Hua Sai in January 1989: one totally CP-owned (Nakorn Farms) and one a joint venture with Mitsubishi Corporation of Japan (Thai Prawn Cultivation Center, TPCC). Both include: a hatchery, nursery and feed mill. Nakorn Farms' grow-out ponds totaled 96 ha, TPCC's 80 ha. CP harvested its first shrimp from 10 ponds (2 ha each) in February 1990 and completed a cold-store and processing plant in April. CP reportedly emphasizes quality control for the demanding Japanese market.

TPCC and Nakorn farms have prospered with a stocking density of 30 pl per square meter, and harvests have averaged 6 t per hectare. CP technicians characterize food conversion ratios and shrimp size at harvest as excellent. Nakorn Farms functions solely as a shrimp producer, selling its harvest to the highest bidder, while TPCC is a long-term, vertically integrated joint venture with Mitsubishi. Its overseas market is 90 percent Japanese and 10 percent American. The CP feed mill in Hat Yai is operating at full capacity but demand in the Hua Sai area is such that additional feed supplies must be shipped down from CP's main mill in Mahachai, the world's largest. TPCC's cold store/processing plant opened in June 1990 with a capacity of 2,000 t per year. TPCC's 1990 production

will probably be around 1,000 t with the remaining capacity filled by local purchases.

The TPCC plant has passed a stringent inspection by a Swiss quality control firm and is hoping for a speedy entrance into international markets. All exports are currently shipped from Songkhla's deepwater port. TPCC has no plans for expansion of grow-out ponds at present. The company recently floated a scheme to initiate a contract system with neighboring growers, but this plan met with little enthusiasm. The company intends to continue its 30 pl stocking rate for the next 10 years, but technicians have expressed concern about future pollution from neighboring small-scale ponds owned by local farmers, which have proliferated at an alarming rate.

IV. OVERDEVELOPMENT PROBLEMS

Between October 1989 and October 1990, the prawn growing area in the Ranod-Hua Sai area tripled from 1,600 to 4,800 hectares. Besides Aquastar and CP, there are a dozen medium-sized shrimp culture companies with 10-20 ha ponds. All told, large and medium-sized companies probably operate between 720-800 ha of ponds. The remaining 4,000 ha belong to small growers, most of whom have converted their paddy fields into 1 or 2 ha shrimp ponds during 1990, stimulated by resurgent high prawn prices. As of October 1990, according to the District Officer of Ranod, there were 986 shrimp growers in the District alone, and 1,436 ponds covering 1,230 hectares. To finance the ponds, small growers have turned to four new banks in Ranod and the government loan office for agricultural cooperatives.

The pattern of rapid over-development and ecological disaster, as happened in Taiwan and the central provinces of Thailand, appears to be repeating itself in southern Thailand. In general, ponds have been dug randomly along the coast. Lack of adequate financing and ignorance of proper construction methods has resulted in leaking dikes, poor water quality, and reckless discharge of effluents into canals or the ocean. In a rush for instant profits, small growers have overstocked their ponds to as high a density as 50-60 pl, and in response to the resultant stress and viral disease, have dumped antibiotics into ponds, producing resistant strains of virus. Growers have also carelessly discharged saltwater effluents into freshwater canals. The resultant damage to rice paddies prompted a 300-man protest by Hua Sa rice farmers in March 1990. Disease has already caused serious losses in the Amphoe Muang and Pakpanang districts of Nakhon Si Thammarat, where the same canals are used for both intake and drainage. Even some of Aquastar's ponds in Hua Sai have reported unexpectedly poor harvests. Joining the rush for quick profits are "wildcat" prawn growers who rent paddy land for 2 or 3 years, overstock to skim off a few quick harvests, then leave the land ruined by sludge and salinity.

Aware of the environmental threat posed by unchecked development, Songkhla Governor Niphon Bunyaratano recently convened a series of three meetings with fisheries and research officials and representatives of the shrimp culture industry, including Aquastar and CP. As a result, Governor Niphon has drafted provincial policy guidelines for shrimp aquaculture. The governor of Nakhon Si Thammarat is expected to promulgate a similar policy for his province in the near future.

Governor Bunyaratano's provincial policy includes prohibitions against 1) the drainage of effluent into fresh water canals or nearby rice fields, 2) dumping of post-harvest sludge into canals or ocean, 3) pumping artesian well water into prawn ponds 4) drainage pipes which reach less than 10 meters into the ocean, and 5) the digging of ponds in the vicinity of Songkhla Lake. Ponds must be no further than 2 kilometers from the Gulf of Thailand and no closer than 100 meters from a fresh water canal. Permits will be required from the Harbor Department for new ponds, and to install intake or drainage pipes in the ocean. Permits will also be required from the Highway Department for pipes that pass under the coastal roadbed.

The coastal salt-water rearing of tiger prawns is a new field and little is known about its effects on the environment. Bechtel Corporation is currently conducting an environmental impact study for Aquastar which will be completed in 7 to 8 months. CP also has an active research section. Songkhla's National Institute of Coastal Aquaculture (NICA) in conjunction with the Science and Technology Development Board (STDB), and Hat Yai's Prince of Songkhla University, are also conducting research projects on the environmental consequences of shrimp culture along the Ranod-Hua Sai Littoral. What is needed, according to all technicians interviewed for the report, is baseline data for monitoring future effluent drainage into the Gulf of Thailand. The effluent itself is totally organic with no minerals, fertilizer, pesticides, etc., and provides an additional

food source for marine life. However, research is needed to determine the carrying capacity of the gulf, and the level at which too much effluent will negatively affect the oxygen content of seawater.

Unlike the central provinces, the Ranod-Hua Sai area is not threatened by industrial pollutants. (In fact, zoned for agriculture, the area suffers from frequent power failures.) The major threat facing the shrimp culture industry in Ranod-Hua Sai is the virus infection Monodon Baculovirus (MBV), which has devastated the central provinces. In a six month survey of eight hatcheries on the Gulf of Thailand, the Andaman Sea and in Malaysia, a trout pathologist found that 95 percent of the larvae hatched from wild brook stock were afflicted with MBV. However, once the post larval stage is reached in grow-out ponds, the virus disappears, unless the pl are under stress from poor water quality, lack of oxygen, overfeeding, overstocking and other factors. Rather than spreading from pond to pond like an epidemic, the virus causes death only when prawns are under stress. A Kasetsart University consultant to several shrimp culture companies in Samut Sakhon reports that companies which maintain environments free of stress continue to reap rich harvests despite the heavy virus devastation in neighboring ponds. It therefore appears that Southern Thai growers who neglect water quality and recklessly overstock will reap the consequences in disease, but that conscientious growers, large or small, can enjoy long-term profit as long as they practice good management techniques.

A more ominous development is the 1-month mortality syndrome reported in the central provinces and some Hua Sai ponds. Aquastar's losses in Hua Sai have ranged between 11 and 83 percent. The cause of the 1 month mortality syndrome is as yet unidentified, although 82 percent of the affected pl displayed blisters which may result from a chemical infection induced by pesticide run-off from nearby paddy fields. Some shrimp growers pump fresh water from canals into the ponds in order to increase shrimp growth rates. Provided intake and drainage remain an enclosed seawater system, ponds should remain relatively free of this disease. However, the possibility that other diseases may emerge in future cannot be discounted. "This is a new field," observed one Aquastar technician, "and we are all groping our way."

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SOURCE

U.S. Consulate, Songkhla, Thailand, November 19, 1990.

ENDNOTES

1. All quantities are expressed in live (whole) weight.

2. For details, see Paul Niemeier, "Thailand's Shrimp Aquaculture," *International Fishery Reports* (IFR 89/95), November 28, 1989.

4

EUROPE

European production is limited as climatic conditions are generally not suitable to most of the continent for extensive and semi-intensive operations. Some semi-intensive farms could be built in southern Europe (e.g. Greece, Italy, Spain, and Portugal) where climatic conditions are most favorable. Growers in these temperate climates, however, will have difficulty competing with low-cost Asian and Latin American growers enjoying tropical growing conditions.

Western European countries conduct extensive research into shrimp culture biology and methods, but commercial harvests are small. This research is often applied to projects in the developing world. Countries located in the southern areas of Western European have imported Asian species suitable to their climate (e.g. *Penaeus japonicus).* A relatively cold climate, high labor costs, and scarce land all serve to constrain the development of Western European shrimp culture.

Eastern European countries and Russia have no crustacean farms, primarily because of inappropriate climatic conditions. At least two countries, however, report preliminary research. Romania is studying crayfish culture along its Black Sea coast and Hungarian researchers are studying the potential of geothermal ponds for freshwater shrimp culture.

4.1

EASTERN EUROPE AND RUSSIA

Aquaculture in Russia and in East European countries is primarily devoted to the culture of freshwater fish. There is no shrimp culture, although a few countries have begun minor experimental studies in shrimp breeding. Climatic conditions preclude significant commercial development of shrimp culture in most of these countries. Only Russia reported a significant trade in shrimp products; it also has an important shrimp fishery.

CONTENTS

I. AQUACULTURE

Except for Russia, the East European countries[1] have only minor aquaculture industries, although harvests increased slightly during the 1980s. These countries harvested over 500,000 metric tons (t) in 1989, a 15 percent increase over the 440,000 t landed in 1985 (appendix A). The most widely cultivated species in Eastern Europe was the common carp, which accounted for over 50 percent of each countries' cultured harvests between 1985-88. Albania was an exception to this. None of the East European countries cultured marine fish or shellfish commercially, but Russia reported small experimental salmon harvests in the Pacific.

During 1984-89, **Albania** showed the largest total increase in its aquacultural production (118 percent increase in the 1989 aquacultural harvest over the 1984 harvest), but its total harvest (2,600 t) amounts to barely 10 percent of most other East European harvests. Several other East European countries registered increases exceeding 20 percent. Among them were: **Poland** (29 percent), **Hungary** (25 percent), and the former **German Democratic Republic** (24 percent). **Czechoslovakia** (10 percent) and **Yugoslavia** (4 percent) kept their own, while **Romania** (-2 percent) and **Bulgaria** (-20 percent) actually registered decreases in their aquacultural production during the last 6 years.

The average annual rate of increase (or decrease) in the aquacultural production shows a similar pattern. Albania's output increased at a 20 percent annual rate, while Bulgaria's diminished at a 3 percent annual rate. Romania's production remained stagnant, but it should be pointed out that FAO did not receive reliable statistics on that country's aquacultural production for the past 5 years and that its present status can, at best, only be estimated.

The **Soviet Union**[2] had the largest aquaculture harvest, ranging from 293,300 t in 1985 to 364,800 t in 1988 (appendix A). It harvested large amounts of common carp, silver carp, and whitefish. These three species accounted for 98 percent of the Soviet cultured harvests between 1985-89. In addition to these three important species, the Soviet Union has been harvesting small amounts of grass carp, sturgeon,

salmonids, flatfish, mullets, scallops, mussels, and a large amount (3,000 t) of brown algae.

Each of the East European countries produced less than 10 percent of the Soviet aquacultural output (appendix 1). **Romania** harvested over 38,000 t of unspecified freshwater fish (probably carp) annually, and small amounts of crayfish, which peaked in 1986 with 30 t, but declined to negligible amounts by 1989. **Poland**'s cultured harvest consisted of common carp, trout, and a small amount of unspecified freshwater fish. The former **German Democratic Republic** (GDR) only cultured rainbow trout and various species of carp. Landlocked **Hungary** has been researching the use of geothermal waters for the culture of various species of fish, including catfish and eel. Carp, however, comprises most of the Hungarian aquacultural production. **Czechoslovakia** is also landlocked and cultures common carp, trout, northern pike, and pike perch. Former **Yugoslavia**'s dominant cultured species were common carp and Mediterranean mussel. **Bulgaria**'s primary species was common carp, but the harvest also included silver carp, rainbow trout, and small amounts of Mediterranean mussels. **Albania** had the smallest aquaculture harvest, less than 3,000 t annually between 1984-89, except in 1988 when it peaked at 3,732 tons. Albania was the only East European country which did not harvest common carp, its primary species were mussels, bighead carp, and rainbow trout.

II. CAPTURE FISHERY

Capture shrimp fisheries are of only minor import to Russia and Eastern Europe (appendix B). The former **Soviet Union** conducted the only fishery of any importance. The catch was small however--23,500 t in 1990--or only two tenths of one percent of the total Soviet fisheries catch of about 10 million tons. The Soviets caught northern prawn (*Pandalus borealis*) in the North Atlantic and in the Barents Sea. Atlantic landings accounted for over 90 percent of the Soviet catch during the 1980s, except in 1987 when Pacific pink shrimp from the Russian Far East contributed over 35 percent of the catch. The Soviet Union reported a new fishery for deepwater rose shrimp (*Parapenaeus longirostris*) off West Africa in 1987, but no details are available on its current status. The former **GDR** was the only East European country reporting more than a negligible shrimp catch between 1981 and 1990. The GDR fishery peaked in 1986 and was comprised almost exclusively of knife shrimp (*Haliporoides triarthrus*) caught in the Indian Ocean. **Bulgaria** reportedly caught pink shrimp in the northeastern Pacific during 1983, 1985, and 1986. **Romania** caught small amounts of crayfish and freshwater crustaceans from 1981 to 1988 when this fishery apparently ceased.

III. SHRIMP CULTURE

The Soviet Union and the East European countries report almost no culture of crustaceans (appendix C). Only a few preliminary research studies have been reported. The **Hungarian** Fish Culture Research Division studied the use of geothermal waters to culture prawns. **Romania** was the only East European country actually culturing crustaceans. The Romanians cultured freshwater crayfish (*Astacus* and *Cambarus*). The Romanian Institute of Marine Research (IMR) has reportedly conducted preliminary studies on the intensive culture of marine shrimp (*Penaeus duorarum*). The IMR was considering sites along the Black Sea, but the researchers did not recommend shrimp culture as a priority government activity.

The former Soviet republics and East European countries are located in the northern latitudes, where shrimp is difficult to culture. However, **Russia** has been discussing the possibility of constructing an enclosed intensive shrimp facility in joint venture with foreign companies. The Far East would provide an opportunity for Russia and foreign investors to tap into the large Japanese market. Recently, **Albania** has been exploring shrimp culture with the assistance of some foreign investors. The newly elected Albanian Government is extremely interested in joint ventures with foreign companies and shrimp culture is one of its top priorities because the product could be exported to Western Europe for hard currencies. There is also some potential for other species, including eels, trout, and seabass. The more southern countries (**Romania**, **Bulgaria**, **Yugoslavia**, and **Albania**) have the most favorable climate for culturing shrimp. Even these countries, however, are at a serious disadvantage compared to tropical countries where shrimp can be produced by low-cost extensive and semi-intensive systems and harvested two or three times a year.

IV. TRADE

Russia and Eastern Europe have only a limited trade in shrimp products (appendices D and E). The two countries with a commercial shrimp fishery, **Russia** and the former **GDR**, export a substantial portion of their catch. The Russians exported about 8,000 t of shrimp in 1990, mostly to the European Community (EC). The GDR was the only East European country to export shrimp to Japan (47 t in 1981) between 1980-91. **Bulgaria** exported close to 300 t of shrimp to the EC in 1981, 1983, and 1985. **Poland** also exported 300 t in 1982 to the EC. Between 1986-90, the **GDR** was the only East European exporter of shrimp to the EC. Shipments to the United States from East European countries (Bulgaria, GDR, Poland, and Yugoslavia) were negligible.

Poland reported the only notable shrimp imports. The effects of privatization and the policy of allowing small companies to operate independently of governmental supervision is showing results in Poland. Several private Polish companies began to import frozen shrimp from the Netherlands. In 1989, a relatively large amount of 3,500 t was imported and profitably sold on the Polish market. The following year, these imports almost doubled (to 6,000 t) and it is likely that they will continue to increase. This new trend, however, is not yet showing in any other East European country.

This overview was prepared by Forrest Nielsen in July 1992.

SOURCES

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ENDNOTES

1. The East European countries include: Albania, Bulgaria, Czechoslovakia, the former German Democratic Republic, Hungary, Poland, Romania, and the former Yugoslavia.

2. The terms: Soviet Union, the German Democratic Republic, and Yugoslavia are used in this report since the statistical data refer to these three states prior to their disappearance during 1990-1992.

Appendix A.--Eastern Europe. Fish culture harvest, 1984-1989.

Country/Species	Quantity						Average Growth ('84-89)	
	1984	1985	1986	1987	1988	1989	Annual	Total
	Metric Tons						Percent	
Albania								
Carp								
Crucian and grass	10	10	12	5	2	14		
Bighead	250	250	300	272	302	346		
Cyprinds	10	20	48	42	62	126		
Other freshwater fish	1	6	30	20	11	7		
Rainbow trout	20	20	22	22	245	270		
Mullets	...	...	1	1	3	1		
Mediterranean mussel	902	1,752	1,808	1,330	3,107	1,840		
Subtotal	1,193	2,058	2,221	1,692	3,732	2,604	20	118.3
Bulgaria								
Carp								
Common	12,584	7,633	8,621	10,024	9,527	9,200		
Silver	950	1,709	2,127	959	959R	959R		
Rainbow trout	1,000	1,178	1,333	1,514	1,554	1,455		
Mediterranean mussel	37	40	57	153	100	Negl		
Subtotal	14,571	10,560	12,138	12,650	12,140	11,614	-3	-20.3
Czechoslovakia								
Common carp	15,500	15,896	17,030	16,652	17,240	17,628		
Trench	322	482	378	419	428	466		
Northern pike	345	309	375	357	343	342		
Other freshwater fish	2,020	1,883	2,156	2,032	2,089	1,725		
Trouts	1,000F	1,055	1,112	1,093	925	956		
Pike perch	254	188	183	183	222	174		
Subtotal	19,441	19,813	21,234	20,736	21,247	21,291	2	9.5
Germany DR								
Carp								
Common	12,867	13,539	13,121	12,810	13,960	14,331		
Grass	35	52	72	81	64	44		
Silver	81	112	141	141	413	791		
Bighead	72	64	133	141	117	161		
Rainbow trout	5,625	6,259	6,899	7,661	7,028	7,804		
Subtotal	18,680	20,026	20,366	20,834	21,582	23,131	4	23.8
Hungary								
Carp								
Common	16,272	10,113	9,713	11,406	12,542	15,029		
Grass	...	349	482	422	383	343		
Silver	...	4,350	4,797F	3,674	2,961	2,582		
Bighead	...	2,543	2,520	1,877	1,642	2,051		
Trench	-	-	13	NA	13	7		
Other freshwater fish	...	636	691	98	139	189		
Wels catfish	10	80	85	69	98	97		
Pike-perch	-	-	20	18	27	26		
European eel	...	NA	NA	115	90	39		
Rainbow trout	191	237	266	269	228	185		
Subtotal	16,473	18,308	18,587	17,948	18,123	20,548	4	24.7
Poland								
Common carp	NA	18,189	16,714	18,472	21,824	21,824R		
Other freshwater fish	NA	395	400	400	400	400R		
Trouts	NA	1,515	1,570	1,600	3,727	3,727R		
Subtotal	NA	20,099	18,684	20,472	25,951	25,951R	6	29.1
Romania								
Freshwater fish	NA	38,900	38,000F	38,000F	38,000F	38,000F		
Crayfish	NA	25	30	11	-	Negl		
Subtotal	NA	38,925	38,030	38,011	38,000	38,000	0	-2.4
USSR								
Carp								
Common	NA	215,530	232,235	246,860	252,877	255,721		
Grass	NA	1,092	1,070	1,119	158	365		
Silver	NA	65,000F	78,198	88,262	98,342	87,095		
Sturgeons	NA	150F	170	150	170	250		
Whitefishes	NA	6,500F	6,607	7,071	5,962	5,181		
Salmons								
Keta	NA	...	4	10	9	Negl		
Sockeye	NA	...	1	Negl	2	Negl		
Salmonids	NA	1,310F	1,309	1,634	1,944	2,173		
Flatfishes	NA	Negl	3	3	8	Negl		
Mullets	NA	100F	161	88	77	Negl		
Mediterranean mussel	NA	70F	79	106	170	206		
Japanese scallop	NA	40F	49	62	64	104		
Phaeophyceae (algae)	NA	3,500F	3,615	3,459	5,000	3,070		
Subtotal	NA	293,292	323,501	348,824	364,783	354,165	4	20.8
Yugoslavia								
Common carp	NA	13,531	12,917	13,042	13,094	13,322		
European eel	NA	52	48	49	19	10		
Trouts	NA	200	250	250F	300F	300R		
Seabasses	NA	20	100	170F	200F	200R		
Gilthead seabream	NA	5	10	35F	60	100F		
European flat oyster	NA	78	154	64	48	185		
Mediterranean mussel	NA	731	1,085	1,076	1,370	1,093		
Subtotal	NA	14,617	14,564	14,686	15,091	15,210	1	4.1
Total	NA	437,698	437,861	468,763	520,262	512,514	3	17.1

R-Repetition of data reported in prior year(s) F-FAO estimate
Negl-negligible
...-Not available, but included elsewhere
NA-Not available
Source: FAO. "Aquaculture Production," FAO Fisheries Circular No. 815. Rome, various years.

Appendix B.--Eastern Europe. East European and Soviet shrimp catch, 1981-1989.

Country	Year									
	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
	Metric Tons									
USSR*	11,825	16,322	29,938	44,497	33,665	11,544	12,040	13,741	15,050	23,450
East Germany	523	561	639	651	882	982	740	674	829	884
Bulgaria	-	-	267	-	332	41	-	-	-	-
Albania**	-	-	-	...	...	...	154	220	208	NA
Romania**	58	32	62	18	25	30	11	-	-	NA
Poland**	-	1	-	1	3	5	9	7	7	NA
Czechoslovakia	-	-	-	-	-	-	-	-	-	-
Hungary	-	-	-	-	-	-	-	-	-	-
Yugoslavia	-	-	-	-	-	-	-	-	-	-
Total	12,406	16,916	30,906	NA	NA	NA	12,954	14,642	16,094	NA

* Includes freshwater crustaceans, under 400 t annually.
** Freshwater crustaceans, including crayfish. No marine shrimp catch.
...-Data not available because shrimp was included with other species
NA-Not available
Source: FAO. Yearbook of Fishery Statistics. Rome, various years.

Appendix C.--Eastern Europe. Cultured harvest of crustaceans, 1984-1989.

Country	Year					
	1984	1985	1986	1987	1988	1989
	Metric Tons					
Romania	18	25	30	11	-	Negl
USSR	-	-	-	-	-	-
Albania	-	-	-	-	-	-
East Germany	-	-	-	-	-	-
Poland	-	-	-	-	-	-
Bulgaria	-	-	-	-	-	-
Czechoslovakia	-	-	-	-	-	-
Hungary	-	-	-	-	-	-

Negl-negligible
Source: FAO. "Aquaculture Production," Fisheries Circular No. 815. Rome, various years.

Appendix D.--USSR. Shrimp* exports to major markets, 1980-1991.

Country	Year											
	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	Metric Tons											
Japan	121**	173**	355**	34**	548**	487**	352**	NA	504	910	1,373	1,779
EC	3,010	1,300	1,346	336	2,732	1,842	356	162	681	2,203	6,174	NA
United States	-	511	17	2,164	126	200	250	-	-	-	446	18
Total	3,131	1,984	1,718	2,534	3,406	2,529	958	NA	1,185	3,113	7,993	NA

*Includes: Fresh, frozen, live, salted, and other prepared shrimp products.
** Listed as shrimps, prawns, and lobsters.
NA-Not available
Source: Japan Tariff Association. Japan Exports and Imports. Tokyo, various years.
Office for Official Publications of the European Communities. Eurostat. Luxembourg, various years.
U.S. Department of Commerce, Bureau of the Census. "United States Imports." Washington, various years.

Appendix E.--Eastern Europe†. Shrimp* exports to major markets, 1980-1991.

Country	Year											
	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	Metric Tons											
Japan	-	47	-	-	-	-	-	NA	-	-	-	-
EC	-	254	367	288	-	316	613	587	387	429	253	NA
United States	18	37	-	-	-	-	46	-	25	16	19	-
Total	18	338	367	288	-	316	659	NA	412	445	269	NA

†Albania, Bulgaria, Czechoslovakia, German Democratic Republic, Hungary, Poland, Romania, and Yugoslavia.
*Includes: Fresh, frozen, live, salted, and prepared shrimp.
** Listed as Shrimps, prawns, and lobsters.
NA-Not available
Source: Japan Tariff Association. Japan Exports and Imports. Tokyo, various years.
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4.2

WESTERN EUROPE

Western European nations conduct extensive research into shrimp culture biology and methods, but commercial harvests are small. Much of this research is applied in projects in the developing world, either as foreign aid or direct investment. Six European countries engage in commercial shrimp culture: France, Italy, Portugal, Spain, Sweden, and Turkey. European shrimp growers have imported Asian species which are suitable to their climate (e.g. *Penaeus japonicus*). Several Western European countries are now experimenting with other tropical species, and Sweden has long cultured *Macrobrachium rosenbergii*, a tropical freshwater species. European countries in general do not have the potential to compete with the world's top shrimp producers because of colder climate, higher labor costs, and the scarcity of land for aquaculture sites. These factors, combined with the stable supply of foreign-grown and wild-caught shrimp (appendix A), constrain European cultured shrimp harvests.[1]

CONTENTS

COUNTRY REPORTS

FRANCE

France has one of the most varied aquaculture industries in the world. Because its territory spans both the cold North Atlantic and the warm Mediterranean, France can successfully culture a great variety of species. Though many forms of French shellfish culture date back centuries, shrimp culture is very recent. Experimental shrimp culture along the southern Atlantic and Mediterranean coasts of France began during the 1960s.[2] Experimental farms for *P. japonicus* utilized small pond sites, and succeeded in raising just over one ton of shrimp during their first two years of production. Commercial production began during the 1970s. Commercial culture remains small by world standards, but has been successful. France is a leader in shrimp culture research, and participates in shrimp culture projects abroad. France is also an important market for seafood, and imports large amounts of both cold water and tropical shrimp.

French domestic cultured shrimp production is quite small, especially in relation to the overall shrimp market in France. During 1985,United Nations Food and Agriculture Organization (FAO) statistics show French marine shrimp production at only 3 tons

(appendix B).[3] In comparison, France imported over 35,000 t of shrimp during 1986, and catch exceeded 2,500 tons.[4] In 1986, farmers expanded production to 11 tons, using a total of 230 hectares (ha) divided between 65 production sites.[5] FAO statistics show no harvest of *P. japonicus* in France after 1988, when French farmers harvested 14 t of cultured *P. japonicus*. Because the 1989 figure is the most recent one available for French shrimp culture, it is unclear if France has discontinued *P. japonicus* culture.[6] According to FAO, however, French shrimp farmers harvest increasing amounts of the freshwater species *Macrobrachium rosenbergii*. FAO statistics show 280 t of *M rosenbergii* were harvested during 1989, an increase of 70 percent from the 1988 harvest of 195 tons.

Though shrimp culture is not likely to become a large-scale industry, France is very active in shrimp culture projects abroad. France, in particular, has initiated several overseas projects, and conducts research on shrimp feeding, maturation, and semi-intensive culture techniques. France provides funding and technical assistance for shrimp culture projects in Francophone Africa as well as in Oceania.[7] In addition, France carries out extensive research into shrimp culture methods and biology at the Center for Research in Marine Ecology and Aquaculture. Private ventures, such as **SANOFI**, also conduct research. French researchers have made significant breakthroughs in shrimp feeding. In addition to continuing work with *P. japonicus*, French aquaculturists are now also experimenting with *P. chinensis* and *P. vannamei*. France also hosts a thriving commercial hatchery industry: though French farmers produced only 11 t of *P. japonicus* during 1986, hatcheries produced 33 million shrimp post larvae during that same year.

The engines for shrimp culture research and production are **IFREMER** (Institut Français de Recherche pour L'Exploitation de la Mer) and **SANOFI**, one of France's largest international businesses. IFREMER created **France Aquaculture** during 1979 to act as its "commercial operation," marketing the saleable assets which IFREMER's research and development programs produced worldwide. During 1989, SANOFI acquired 70 percent of France Aquaculture, and thus obtained first access to France Aquaculture's technological developments. This partnership between IFREMER (the minority holder of France Aquaculture with the remaining 30 percent of stock holdings) and SANOFI has proved quite successful. With funding from SANOFI and the expertise of IFREMER's 200 scientists, France leads Europe in shrimp culture technology and research. What is more impressive, however, is that France is a strong exporter of this technology to foreign shrimp harvesters.[8]

Though it has diversified and expanded, cultured shrimp production in France has not grown to any impressive size. Siting is less of a problem in France, as it has some 27,000 ha of man-made salt marshes suitable for raising *P. japonicus*. However, these areas are also suitable for culturing more profitable and well-suited species (such as mussels and oysters, which are the backbone of French aquaculture). Thus French shrimp culture does not promise to become commercially important, at least as long as foreign supplies remain plentiful. Undoubtedly, however, France will continue to participate in shrimp culture projects in Francophone Africa and Oceania.

ITALY

Italy is just beginning to experiment with shrimp culture as part of a national plan to increase aquaculture harvests of various fish species. Italy's shrimp production has historically consisted primarily of capture harvests of warmwater species, including *P. longirostris,*[9] but decreasing stocks and increased pollution of Italy's waters have heightened Italy's interest in aquaculture research.

Italy first cultured shrimp in 1981 when the Institute for the Biological Utilization of Lagunas (National Research Council) in Lesina harvested 0.2 t of *P. japonicus.*[10] The shrimp were cultured in the brackish waters of the Laguna di Lesina, on the southeast coast of Italy, and the Laguna di Grado, on the northeast coast. By 1982, the Institute increased its harvest to 5 t after successfully controlling reproduction in captivity.[11]

Extensive breeding trials of *P. japonicus* to commercial size have been successful.[12] In 1982, 400,000 pls were stocked in the Laguna di Lesina, yielding approximately 3 tons. Extensive monoculture in the Laguna di Lesina has produced yields of 370 kg/ha. Intensive monoculture in the same lagoon (1 ha) has produced yields of more than 1 ton per hectare. Breeding trials of shrimp in extensive monoculture were also conducted in the brackish waters of the Laguna di Grado. A "valle de pesca" (12 ha) in the lagoon was stocked with 80,000 pls of *P. japonicus*, and a yield of about 75 kg per ha was

obtained in 4 months, with total production of about 1 ton.

Commercial aquaculturists in Italy showed interest in *P. japonicus* farming as a result of these studies. Hatcheries were planned, and by 1985, annual production was projected at 1,000 t per year.[13] Currently, *P. japonicus*, *P. monodon,* and the native European *P. kerathrus* are being cultured on the northern Adriatic coast of Italy.[14]

Giant freshwater prawns (*Macrobrachium rosenbergii)* have also been reared experimentally in Italy. Aquaconsult S.r.l., an Italian consulting firm, was involved from 1981 to 1984 in the design and construction of a greenhouse aquaculture facility in Milan designed to rear the species.[15] A batch of post-larvae, shipped to the farm from the U.S. in 1984, reached market size in ten months. A good market was predicted for the prawns in Italy as they sell for a high price.

The Italian Government in 1990 ended its second Three-Year Plan for the development of Italian fisheries and aquaculture. The Plan included legislation to improve aquaculture facilities, appropriations for 2 aquaculture ventures, and approval of 50 aquaculture research projects.[16] The third Three-Year Plan subsequently went into effect in 1990, with an emphasis on increasing Italy's self-sufficiency, in part by supporting freshwater and marine aquaculture.[17] Thus, although Italy's aquaculture development plans do not focus specifically on shrimp culture, but rather on species which currently dominate Italian aquaculture - such as trout - an increased emphasis on aquaculture generally should aid in the development of Italy's shrimp culture.

PORTUGAL

Portuguese shrimp culture is largely experimental. Portuguese aquaculturists began experimental shrimp culture during 1985 under the authority of the Instituto Nacional de Investigacão das Pescas (NIP). Experiments used *P. japonicus* broodstock obtained from Spain. Portuguese scientists succeeded in breeding *P. japonicus* during 1987, and have successfully cultured their own fry since then.

Scientists have also conducted experiments in saltwater marsh ponds in central and southern Portugal. These have been relatively successful, and Portuguese shrimp farms produced 6 tons of cultured shrimp in 1989. There is much room for expansion, but it is unlikely that Portugal will develop a commercially important shrimp culture industry.

SPAIN

Spanish aquaculturists first introduced *P. japonicus* during the 1980s. Since then, Spanish farmers have successfully cultured *P. japonicus* using extensive methods along Spain's south Atlantic shore.[18] Spanish shrimp culture expanded rapidly during the mid 1980s. During the late 1980s however, Spanish *Palaemon serratus* (common prawn) harvests (which had formed the majority of harvests during the early and mid 1980s) decreased sharply. Because harvests of P. japonicus continued to increase steadily throughout the 1980s, total Spanish cultured shrimp harvests have continued to increase. Though little information is available on current Spanish harvests, Spain operated a thriving hatchery industry during the mid 1980s. Several commercial shrimp hatcheries in Spain alternate between fish (from November to March) and shrimp (April to September) production in order to maximize efficiency. Only one hatchery, Mariscos de Estero S.A. (MAREWSA) in Ayamonte, Huelva, is dedicated exclusively to shrimp fry production. Despite this, Spain produced over 24 million post larvae during 1986, and production has presumably expanded. Several other companies have begun construction of hatcheries, some in association with small growout facilities. Spain also has many so-called "backyard" hatchery operations. These consist of private individuals hauling in a truckload of seawater, purchasing nauplii from a sourcing station in Esmeraldas, and producing as many as 1 million post larvae per cycle. Interestingly enough, these "backyard" operations have reportedly been quite successful, because of their remarkably low start-up costs.[19]

According to the last available FAO figures, Spanish shrimp farmers harvested 15 t of *P. serratus* during 1989.[20] This harvest is down sharply from the high of 40 t of *P serratus* which Spanish farmers harvested during 1987. Harvests of *P. japonicus*, in contrast, have increased steadily. From harvests of only 16 t during 1986, Spanish farmers had increased production to 54 t by 1989. Considering the informal hatchery operations described above, however, FAO statistics may not include all Spanish shrimp culture because this "backyard" culture is not easily monitored.

Spanish shrimp culture research has focused on stocking density. Spain modelled its experimental culture on French methods (e.g. Spanish hatcheries were built on the French model and supplied with French stock). Spanish aquaculture research also benefits from European Community aquaculture grants, which finance both research and, in some cases, farm mechanization and expansion. For example, The EC authorized funding for a pilot aquaculture program in the Andalucia region during July 1991. **Pescanova**, a huge Spanish fisheries conglomerate, began experimental operations with black tiger shrimp (*Penaeus monodon*) during 1988 at a Mediterranean site. Experimental operations using other species are reportedly also underway. Test marketing ventures to determine if Spanish consumers will accept the new species are reportedly also being conducted.

Shrimp culture in Spain has experienced steady growth, and shows perhaps the best promise of expansion among all Western European countries. Not only is this because many regions of Spain qualify for "less developed region" funds from the EC, but also because the Spanish coast is among the most favorable in Europe for large-scale shrimp culture. In addition, the regions of Spain suitable for shrimp culture have a chronically large unemployed and underemployed labor base, often with a good working knowledge of fisheries matters. In addition, Spanish consumers have a voracious appetite for seafood, annually consuming more than 30 kg per capita. These factors indicate Spain is more suited to large-scale shrimp culture than other Western European countries. By 1991, Spanish farmers hoped to be producing 400 t of adult shrimp and 4 billion post larvae. This figure, though no production data are available, was probably optimistic.

SWEDEN

Though all of the other shrimp culturing nations of Europe are Mediterranean countries, Sweden has been culturing *Macrobrachium rosenbergii* for more than 15 years. This freshwater species is an Indo-Pacific transplant to Sweden. The only company involved in shrimp culture is **Simontrop Aquaculture AB** (owned by Tetra Pak) in Southern Sweden. The Swedish operation does little growout, producing instead postlarvae for stocking rivers and ponds. Simontrop had hoped to begin commercial *M. rosenbergii* culture using specially warmed ponds, but there is no information on the status of this commercial venture.

TURKEY

Turkey currently harvests a negligible amount of shrimp. However, as both the Government and private sector develop Turkey's freshwater and marine resources, the development of shrimp culture should gain increased attention.

The Ministry of Agriculture, Forestry, and Rural Affairs decided in the mid 1980s to increase the role of fisheries in Turkey's economy, announcing the 1989-1994 "Project for Developing the Production and Export of Fisheries" to supplement the 1984-1989 Fifth Five Year Development Plan which emphasized increased fisheries production.[21] One of the goals of the Project was the establishment of shrimp aquaculture farms, with Government funds provided for investment in and operation of the facilities.

According to the OECD, the Turkish Government has recently introduced various research projects to develop the aquaculture sector and has also encouraged private investment in aquaculture farms along the Aegean and Mediterranean coasts, approving 99 aquaculture investment projects since 1989.[22] The Government is implementing the Project for Development of Aquaculture in Turkey within the framework of the Project for Turkish/Italian Technical Cooperation Programme. In addition, the Beymelek Lagoon Aquaculture Project, with a shrimp production capacity of 10 t, has commenced with contributions from UNDP/FAO, and another Government project is planned which aims to farm 500,000 shrimp larvae per year.[23]

Private investment in shrimp aquaculture has also begun. The Turkish firm, **Rafine Billur Tuz Sanayi**, recently established a shrimp farm near Izmir on the Aegean coast.[24] Another Turkish firm, **Pinar Deniz Urunleri**, which currently farms sea bream and sea bass near Izmir, was considering raising penaeid shrimp in 1988.[25] Cermar Maritime Enterprises, Ltd., a U.K. company, sought partners in 1990 to establish a shrimp farm in southern Turkey.[26]

Turkey is making a concentrated effort to develop an aquaculture sector. If Government-funded research, private investment, and joint ventures continue, shrimp culture could become a viable industry in Turkey.

THE UNITED KINGDOM

The United Kingdom's cold climate precludes shrimp culture harvests. However, British research organizations and companies have been quite active in shrimp culture projects abroad, particularly in former colonies of the British Empire. In particular, **Marine Harvest**, a UK fisheries conglomerate, has been active in many overseas shrimp culture projects (including India and Bangladesh). However, Marine Harvest's parent company, the Dutch giant **Unilever**, put Marine Harvest up for sale during 1991. Therefore, the future of Marine Harvest's role in aquaculture depends entirely on the disposition of the company's new owners.

This report was prepared by Eleanor Sanborn and Helena Riha in July 1992.

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5. Production area and number of sites based on government sources.

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23. OECD, p.10.

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25. *Ibid.*

26. *World Shrimp Farming*, September 1990.

APPENDICES

Appendix A.--Western Europe. Shrimp catch, 1985-90.

Country	Year					
	1985	1986	1987	1988	1989	1990
	Metric Tons					
France	1,982	2,705	2,298	2,286	2,370	2,370
Italy	322	333	423	333	504	507
Portugal	-	202	56	90	475	163
Spain	24,915	16,146	16,414	12,824	20,358	18,838
Sweden	1,602	1,514	1,337	1,295	1,426	1,607
Turkey	NA	NA	NA	NA	NA	NA
United Kingdom	2,197	1,788	3,344	1,780	1,981	1,136
Total	31,018	22,688	23,872	18,608	27,114	24,621

NA -- not available
Source: Food and Agriculture Organization, Yearbook of Fishery Statistics, various years.

Appendix B.--Western Europe. Cultured shrimp harvests, 1985-89.

Country	Year				
	1985	1986	1987	1988	1989
	Metric Tons				
France	3	198	205	209	280
Italy	-	-	-	-	-
Portugal	-	-	-	-	6
Spain	-	56	60	67	69
Sweden	-	-	-	-	-
Turkey	NA	NA	NA	NA	NA
United Kingdom	-	-	-	-	-

NA -- not available
Source: Food and Agriculture Organization, "Aquaculture Production," Fisheries Circular No. 815, various years.

5

MIDDLE EAST

The Middle East has a relatively small aquaculture industry. Countries such as Iran, Iraq, and Israel have developed their aquaculture industries farming freshwater fish (primarily carp). Shrimp aquaculture in the Middle East is in its infancy. Natural conditions such as water salinity and climate are not always favorable, as temperatures can reach extremes. In addition, Muslims and Orthodox Jews do not eat shellfish, almost eliminating the domestic market. Shrimp is not yet cultured in sufficient quantity to enter global markets. As natural conditions are somewhat favorable, and governments are generally supportive, the possibility exists for the successful development of shrimp aquaculture projects.

CONTENTS

COUNTRY REPORTS

IRAN

Iran has an extensive coast, but reports no capture shrimp fishery. The country has the second largest aquaculture industry in the Middle East. Iranian growers harvested 11,000 metric tons (t) of cultured freshwater fish in 1989 (mostly carp), which represents over 30 percent of the total aquaculture production for the Middle East (appendix B). An experimental shrimp project was reportedly underway in 1988.[1] No further information, however, is available.

IRAQ

Iraq has almost no coast and reports no capture shrimp fishing. The country has, however, the third largest aquaculture industry in the Middle East. Farmers harvested 5,000 t of carp in 1989, representing nearly 15 percent of the total Middle East aquaculture harvest. There are no known experimental or commercial shrimp farms in Iraq, but there is some interest. The Arab Federation of Fish Producers sponsored the second seminar on Aquaculture Development of Finfish and Shellfish during the Arab World in March 1990 in Baghdad.[2]

ISRAEL

Israel reports a very small shrimp fishery and has the largest aquaculture industry in the Middle East. Israeli farmers produced a total of 15,400 t cultured fish and shellfish in 1989, or 45 percent of the total cultured harvest in the Middle East (appendix B). Israel is emerging as a world leader in freshwater shrimp culture research (*Macrobrachium rosenbergii*). One researcher developed polyculture techniques for culturing freshwater shrimp in existing fish ponds. Dr. Dan Cohen, a molecular biologist at the experimental farm of the Hebrew University's Alexander Silberman Life Sciences Institute, led the research effort.[3] Israeli consulting groups such as Aquaculture Production Technologies (APT) have subsequently developed intensive culture systems for *M. rosenbergii*. APT also works on culture systems in arid environments. The company is active in several developing countries, including Belize and Jamaica.

Despite these developments, Israeli cultured shrimp harvests are small (appendix A), partially because dietary considerations restrict the domestic market as Orthodox Jews cannot eat shellfish. A recent news release, however, reports that the Shefa-Am factory in Kibbutz Eilon, in partnership with the Tivali vegetarian factory, will be producing "kosher shrimp" and squid from fish proteins. The $10 million plant was built with technology from Japanese and European companies.[4]

KUWAIT

Kuwait reports no shrimp fishery and a very limited aquaculture industry. The country has made limited efforts to assess shrimp culture. The possibility of commercial shrimp culture, however, is unclear. Before the Gulf War, Kuwait was experimenting with marine shrimp culture.[5] The 1982 Shrimp Culture Project assessed the possibility of culturing shrimp in Kuwait. Researchers focused on *Penaeus semisulcatus*, an indigenous species.[6] The outcome of these studies is not known. The Kuwait Institute for Scientific and Industrial Research (KISIR) is studying various marine cage culture systems for a variety of species, including crustaceans. This program was terminated abruptly after the Iraqi invasion in 1990. It is unknown if the KISIR has resumed the study.

LEBANON

Lebanon currently does not farm shrimp.[7] The Government of Lebanon, however, has submitted a prototype extension shrimp farming program proposal to the United Nations Food and Agriculture Organization. The project would cost $250,000 and take place over three years.

OMAN

Oman currently has neither a shrimp fishery nor an aquaculture industry, although small quantities of shrimp have been cultivated (1987-88). One shrimp culture company, the Oman Sea Farms Company, was established in 1984. The farm stocked black tiger shrimp, *P. monodon*, in 90 growout ponds and had a hatchery. Plans called for producing 250 t of shrimp per year,[8] and investors were optimistic. High air and water temperatures induced stress, however, so the shrimp grew more slowly than anticipated. Small harvests were achieved in 1987-88, but the quantities did not meet projections. The farm went out of business in 1989. A consultant for France Aquaculture, which provided technical assistance for the project, believes that the farm could be run profitably.[9]

An Omani-American joint commission has concluded, however, that shrimp aquaculture would not be commercially viable in Oman.[10] There are few appropriate sites in Oman for shrimp farming, and the sites which exist are associated with protected habitats. Development authorization for these areas would be difficult to obtain. The study also found that based on projected costs of operation and development, the return on a shrimp culture project would be less than market interest rates.[11]

QATAR

Qatar currently has no shrimp aquaculture industry and does not intend to develop shrimp culture in the near future.[12] Shrimp culture studies may be conducted in 1994.

SAUDI ARABIA

Saudi Arabia has no shrimp fishery and only a small aquaculture industry. Cultured harvests consist almost exclusively of farmed tilapia. The Saudi Fisheries Company (SFC) has initiated a $1.5 million shrimp culture project. The company produced 10 t of black tiger shrimp (*P. monodon*) in 1989 (appendix

A),[13] and the company exported small quantities to the EC.[14] SFC has carried out trial runs and is now preparing to shift to commercial-scale operations. SFC plans to invest $15 million in a commercial farm operation during the next 10 years.[15]

Although further information is not available, another company was seeking a joint venture partner for a proposed shrimp farm in 1990. The farm had a planned annual harvest of 525 tons.[16]

UNITED ARAB EMIRATES (UAE)

The United Arab Emirates (UAE) reports no shrimp fishery and a negligible aquaculture harvest. The UAE began collaborating with the Kuwait Institute of Scientific Research in 1987 on a shrimp culture project. Experimental trials reportedly met with some success. The Marine Resources Research and Culture Center in Umm Al Quwain has been publicizing the results in an effort to interest industry investors.[17] The only known project was launched by the government in collaboration with a group of local and foreign investors at Khor Kalba creek in Sharjah. Preparation for the project, which will cultivate *P. semisulcatus*, began in early 1989. The $3.3 million farm consists of 12 hatchery ponds and 48 growout ponds.[18]

YEMEN

Yemeni fishermen conduct one of the largest shrimp fisheries in the Middle East. No information is available on the overall aquaculture industry. One group is conducting trial runs of *Penaeus semisulcatus*.[19] The experimental facility has had several problems in the past. Among these are the paucity of low-cost shrimp feed, lack of experienced staff, various technical problems, and shrimp mortalities of up to 97 percent.[20] Despite these drawbacks, the Yemen Fishing Company was formed in 1987 with the intent of establishing shrimp culture farms catering to local and export markets.[21] Information on the success of this venture is unavailable.

This overview was prepared by Joanne Beverly, Helena Riha, and Mark Wildman during July and August 1992.

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13. FAO "Aquaculture Production," *op. cit.*.

14. *INFOFISH International*, March 1989, p. 9. Shrimp exports to the EC totaled 821 t in 1989 and 250 t in 1990. It is not clear what the source of the shrimp is, as FAO reports no trawler catch. FAO, *Yearbook of Fishery Statistics*, 1990.

15. *World Shrimp Farming*, May/June 1992, p. 24; and *INFOFISH Trade News*, October 2, 1990.

16. U.S. Embassy, Dhahran, March 7, 1990.

17. *Fish Farming International*, July 1990, p. 6.

18. *Fish Farming International*, February 1989.

19. ADCP, *A Regional Survey of the Aquaculture Sector in Eleven Middle East Countries*, *op. cit.*.

20. *Fish Farming International*, July 1986.

21. *INFOFISH Trade News*, September 1, 1987.

APPENDICES

Appendix A.--Middle East. Shrimp harvest, 1989.

Country	Production		
	Capture	Culture	Total
	Metric tons		
Bahrain	1,514	-	1,514
Israel	41	2	43
Lebanon	25	-	25
Qatar	182	-	182
Saudi Arabia	-	10	10
Yemen	360	-	360
Total	2,122	12	2,134

Source: FAO, "Aquaculture Production (1986-89)," FAO Fisheries Circular No. 815, Rev. 3, July 1991; and FAO, Fishery Statistics: Catches and Landings, (FAO: Rome, 1991).

Appendix B.--Middle East. Cultured fish and shellfish harvests, 1985-89.

Country	Year				
	1985	1986	1987	1988	1989
	Metric tons				
Bahrain	NA	NA	NA	NA	NA
Iran	7,000	8,802	10,299	10,400	11,000
Iraq	4,500	4,564	4,500	5,000	5,000
Israel	12,954	12,289	14,027	15,156	15,426
Jordan	NA	65	70	70	55
Kuwait	2	3	5	8	10
Lebanon	300	375	200	100	100
Oman	NA	NA	8	5	-
Qatar	NA	NA	NA	NA	NA
Saudi Arabia	NA	28	140	331	1,240
Syria	1,530	1,730	1,730	1,730	1,730
UAE	7	7	9	6	2
Yemen	NA	NA	NA	NA	NA
Total	26,293	27,863	30,988	32,806	34,563

NA - Not available
Source: FAO, "Aquaculture Production (1986-89)," FAO Fisheries Circular No. 815, Rev. 3, July 1991.

Appendix C.--European Community. Shrimp imports from the Middle East, 1986-90.

Country	Year				
	1986	1987	1988	1989	1990
	Metric tons				
Bahrain	-	-	-	94	-
Iran	-	-	-	176	502
Kuwait	-	-	-	254	561
Oman	-	-	-	107	230
Saudi Arabia	316	397	436	821	250
UAE	-	-	-	-	218
Yemen	59	255	-	103	-
Total	375	657	436	1,555	1,761

Source: EC NIMEXE

Appendix D.--Japan. Frozen shrimp imports from the Middle East, 1986-91.

Country	Year					
	1986	1987	1988	1989	1990	1991
	Metric tons					
Bahrain	-	-	13	-	-	-
Iran	121	NA	259	-	37	101
Kuwait	178	68	708		361	6
Oman	-	-	31	59	10	10
Saudi Arabia	68	NA	Negl	-	-	-
UAE	-	-	130	138	25	60
Total	367	68	1,141	197	433	177

NA - Not available
Negl - Negligible
Source: Japan Marine Products Importers Association

Appendix E.--United States. Shrimp imports from the Middle East, 1985-91.

Country	Year						
	1985	1986	1987	1988	1989	1990	1991
	Metric tons						
Bahrain	-	44	1	-	-	12	-
Iran	15	207	239	-	-	-	-
Israel	-	17	-	-	-	-	-
Kuwait	346	119	215	95	30	-	-
Oman	-	-	7	-	-	76	53
Saudi Arabia	264	28	-	-	-	-	-
Syria	-	4	-	-	-	-	-
UAE	-	-	42	6	66	52	8
Total	625	419	504	101	96	140	61

Source: U.S. Bureau of the Census

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NORTH AMERICA

North American shrimp farming is limited to the United States.[1] The United States plays a major role in world shrimp farming, not because of its production, which is insignificant by world standards, but because of its expertise in hatchery and farming techniques. United States researchers, educators, consultants, and entrepreneurs have been marketing this technology since the early 1970s, making a major contribution to the explosion in world shrimp farming which occurred between 1975 and 1990. The United States currently supplies capital, feeds, consulting, equipment, research, publications, education, information, and training to shrimp farmers in at least 25 countries. Shrimp farms are located in the states of Hawaii, South Carolina, Texas, and, to a lesser extent, the Commonwealth of Puerto Rico[2]. Approximately 20 farms produced 1,600 metric t of shrimp from 450 ha of ponds in 1991. Three or four hatcheries supplied the industry with seedstock.

The United States is the largest consumer of shrimp in the world. Per capita consumption has increased steadily over the past decade, but domestic production has not. Increased demand has largely been met by imports (valued at almost $2 billion a year), most of it "farm-raised" from countries like Thailand, Ecuador, Indonesia and China. For the past five years, in an attempt to reduce the billion dollar trade deficit in farm-raised shrimp, public agencies in the United States have been funding shrimp farming research and development at the rate of about $5 million a year. The U.S. Department of Commerce supports shrimp farming through the National Sea Grant College Program, which funds applied and basic research at Texas A&M University, the University of Arizona, the University of California, the University of Hawaii, and other Sea Grant institutions. The U.S. Department of Agriculture supports the industry through its Cooperative State Research Service, which funds a program at Mississippi's Gulf Coast Research Laboratory. This Lab leads a consortium of U.S. research facilities that are attempting to determine the feasibility of shrimp farming in the United States. In addition to federal programs, the states of South Carolina, Texas, and Hawaii also make a significant contribution to shrimp farming research and development. The research and practical experience generated by these programs has made the United States a world leader in shrimp farming technology.

CONTENTS

BACKGROUND

Throughout the 1940s and 1950s, various individuals in the states of Florida, South Carolina, and Texas, experimented with captive stocks of the northern white shrimp (*Penaeus setiferus*) hoping to discover appropriate farming strategies. The National Marine Fisheries Service in Galveston, Texas, began studying hatchery techniques with the northern brown shrimp (*P. aztecus*) in 1963, resulting in the famed "Galveston Method" for raising penaeid shrimp. In 1967, Marifarms, Inc.,

started a shrimp farming operation near Panama City, Florida. It netted off several large bottleneck embayments and stocked them with juvenile shrimp. Later, it abandoned this approach as impractical and tried to raise shrimp in 300-acre ponds. A couple of years later, the project failed.

About this time, other projects began in Florida. Notable among these was the Turkey Point project operated from 1967 through 1972 and funded by Armor and United Brands through the University of Miami. At Turkey Point, larval rearing techniques were refined, species evaluated, and diets developed. The project attempted to utilize the waste heat from a Florida Power and Light nuclear power plant to overcome the climatically restricted growout season. Unfortunately, the presence of tridium in the recirculating water precluded commercial use of the product and the financial backing was withdrawn. Perhaps the greatest contribution this project made to the present day shrimp farming industry was the personnel it turned out. Many of these individuals went on to establish profitable enterprises in Central and South America and remain leaders in the field today.

Another important shrimp farming project was conducted at Crystal River, Florida, from 1972 until 1982. The Crystal River Project was associated with a fossil fuel power plant and funded by the Ralston Purina Company. Perhaps the most significant contribution this project made to present-day shrimp farming technology was the development of commercially viable controlled maturation systems that allowed captive breeding. It was also at this project that researchers first spawned the white shrimp (*P. vannamei*), a species native to the Pacific coast of Central and South America. Today *P. vannamei* accounts for 95 percent of cultured shrimp production in the western hemisphere. In 1972, the staff raised its first batch of *P. vannamei*. After a few experiments, it became increasingly obvious that they had discovered a super species that could survive most of the abuses and stresses of growout ponds. In 1972, Ralston Purina Mariculture Research Center determined that *P. stylirostris* and *P. vannamei* produced better yields than *P. aztecus*, results which were later confirmed in Texas.

Starting in 1972, the University of Arizona, in a joint project with the University of Sonora, Mexico, developed a super-intensive controlled environment shrimp growout system that eventually produced over 100,000 pounds of *P. stylirostris* per ha per year. The project was financed by a series of major corporations (Resorts International, Coca Cola, F.H. Prince, and W.R. Grace), but it was eventually shut down by a viral disease. Currently, The University of Arizona leads the world in the understanding of shrimp diseases, especially viral diseases.

In 1976, Sea Farms, Inc. started a shrimp farm in the Florida Keys, but it soon gave up trying to build ponds in the lime rock lowlands of the Keys and moved the farm to the west coast of Honduras, where it remains one of the oldest and most successful shrimp farms in the Americas.

In the late 1970s and early 1980s, as shrimp farming took off in Latin America and Southeast Asia, only a few farms existed in the United States. The Texas A&M Sea Grant program was the glue holding the industry together. When the U.S. Department of Agriculture (USDA) initiated its shrimp farming program in the mid-1980s, however, there was a surge of new shrimp farming activity in the states of South Carolina, Hawaii, and Texas.

STATE REPORTS

SOUTH CAROLINA

The first documented attempts at shrimp farming in the continental United States took place in South Carolina during the mid-1950s. These farms used low-density techniques along the coast. They captured wild juveniles in coastal impoundments and raised them to market size. These methods were unpredictable because of fluctuating supplies of wild seed, predators, and difficulties with harvesting.

Once commercial supplies of hatchery-produced *P. vannamei* seedstock became available, the farms shifted from low-density production to medium and high-density production. The first company to stock hatchery-reared seed was Palmetto Aquaculture in 1981. When it switched to hatchery-produced postlarvae instead of wild postlarvae, it had better predator control, and, through some mechanical adjustments, improved harvesting efficiency. Over the years, Palmetto Aquaculture has used a number of tidal impoundments and growout strategies. Generally, it has reduced acreage while increasing

production. It makes money if 50% of the seedstock make it to market size.

In 1984-85, South Carolina's Waddell Mariculture Center was constructed to provide research and development support for the shrimp farming industry as well as the overall aquaculture industry. The Center works with marine and brackish water species. At present, about half the effort is in shrimp research and development and the other half is in finfish (striped bass hybrids, redfish) and mollusks (clams, oysters). A prototype hatchery at the Waddell Mariculture Center supplied some farms in South Carolina with disease-free seedstock from The Oceanic Institute in Hawaii in 1992.

Edisto Shrimp Company, one of the first modern shrimp farms in the state, found that by using a highland site, it had much greater control over production. Its ponds could be completely dried between crops to oxidize and remove the organic sludge. Supplemental aeration helped to increase production. On the heels of Edisto Shrimp Company were a number of small, medium-density farms that developed between 1985 and the present. As the years go by, new farms tend to increase densities.

Statewide production of farm-raised shrimp in South Carolina amounted to 172 t (whole weight) in 1987. In 1989, the state had 12 operating shrimp farms and 258 acres of ponds, but, because of the unavailability of postlarvae in the spring of 1989, only about 172 acres actually got stocked. Edisto Shrimp Company, for example, only stocked 60 of its 140 acres. Some of the farms that have been operating for two or three years have honed their management skills and made some money. More importantly, a lot of the small farms found niche markets. It's becoming increasingly clear that the key to success in South Carolina shrimp farming is not just good technology and management, but also good marketing. Family-owned operations seem to be the trend. While there are economies of scale in shrimp farm development, the family-owned and operated farm also has an economic advantage due to reduced labor costs, the availability of small parcels of land and, in many cases, reduced construction costs by do-it-yourself entrepreneurs.

It appears that South Carolina, unlike Texas (which is developing some large corporate farms), will have small, high-density farms. The shrimp farm of the future will be small enough to move all its product in niche markets, markets that will be willing to pay a premium price for a premium product. South Carolina can't compete with farm-raised shrimp from China, Ecuador, and Southeast Asia. The margins are just too small. Large farms will find it difficult to move all of their product in niche markets. If someone is going to make money, it's going to be an entrepreneur with good management, good finances--and good marketing instincts.

TEXAS

The origins of shrimp farming in Texas can be traced to the early 1960s when Harry Cook and co-workers at the National Marine Fisheries Service (NMFS) Laboratory in Galveston, Texas, developed techniques for spawning and larval culture of local species, including *P. aztecus*, *P. duorarum* and *P. setiferus*. The NMFS technique modified the large-tank, community-culture method pioneered for *P. japonicus* larval culture by Japan's Dr. Motosaku Fujinaga, now recognized as the "Father of Shrimp Culture". Harry Cook credits much of his early success at NMFS to the existing algae culture expertise at the Galveston Laboratory obtained through red tide research. The Galveston Laboratory continued to refine larval rearing methods throughout the 1970s and served as an important demonstration and training center for aspiring hatchery biologists worldwide. The methods utilized by the NMFS researchers are still widely known as the "Galveston Method."

In 1968, the Texas Agricultural Extension Service began its shrimp program in Brazoria County. This program, funded through Texas A&M University's Sea Grant College Program, the Brazoria County Mosquito Control District, Texaco, Ralston Purina, and Dow Chemical Company, developed and expanded into 22 ponds. It established the foundation for early shrimp culture production in Texas.

The second Texas A&M Agriculture Extension Service mariculture facility was established near Corpus Christi in cooperation with Central Power and Light Company and Ralston Purina in 1972. Utilizing technology developed earlier at the Brazoria County facility, a production module was designed and constructed at the Barney M. Davis Generating Station to demonstrate the feasibility of shrimp farming. The pilot module demonstrated production capabilities of up to 6,000 pounds of 38-count (heads on) *P. vannamei* and up to 3,000 pounds of 15 count (heads on) *P. stylirostris* in

multiple crops during the 6-7 month south Texas growing season.

Currently, the Texas Agricultural Extension Service (TAEX), a branch of the Texas A&M University System, supports commercial shrimp farming development through short courses, manuals, start-up assistance, disease diagnosis, and so forth. Marine advisory service agents provide personal assistance in locating sites. They also tap TAEX's vast resources for information on engineering, disease, and marketing.

Several universities--including Texas A&M University, the University of Texas, and the University of Houston--are actively engaged in shrimp farming research. Much of the funding for this effort has historically originated from the Texas A&M University Sea Grant Program. Recently, additional funds have been allocated by the USDA.

Construction was begun on 18 one-quarter acre ponds adjacent to the 1,100 acre cooling lake at the Barney M. Davis Generating Station in 1974. These ponds complemented the facilities in Brazoria County and allowed capabilities for testing production technology under the high salinity conditions characteristic of the Laguna Madre, whereas the Brazoria County facilities evaluated production in the lower salinity waters of Galveston Bay. Facilities at both locations were designed to conduct replicated studies using variations in diet, species, stocking densities, water fertilization, and disease control. Major efforts were directed toward improved pond management. Both facilities compared production capabilities of the native *P. setiferus* against two white shrimp species imported from the Pacific Coast of Central America (*P. vannamei* and *P. stylirostris*) and evaluated stocking densities.

In 1980, Dr. Jack Parker resigned from Texas A&M University and founded Laguna Madre Shrimp Farms near Bayview, Texas. Currently, this farm is owned by Taiwanese investors and called Harlingen Shrimp Farms. It began in 1981 with a three phase, 28-hectare, medium-density pond system and a pilot-scale greenhouse-covered hatchery. A second 28-hectare pond module was added in 1982. The pilot hatchery supplied enough seedstock for the entire farm. This was a major turning point in the history of Texas shrimp farming, marking the first time that postlarval availability did not limit pond stocking. In 1983, Laguna Madre Shrimp Farms expanded its pond area to 182 ha and constructed a large permanent hatchery.

With an increasing amount of postlarvae available, a number of shrimp farms started operations in the early 1980s. At first glance, the bays along the Texas coast appear to be ideal for shrimp farming, but that's not the case. Each has its own characteristics in terms of river inflow and salinity. Some tend to go abruptly fresh when it rains. Matagorda Bay, however, is a good bay for shrimp farming. There are already four shrimp farms on its shores. Other farms locate as far south as they can to take advantage of the longer growing season. Unfortunately, the southernmost bay system, the Laguna Madre Bay System, tends to have very high salinities.

In the late 1980s, after realizing that its shrimp farming industry was overbuilt, Taiwan began offering its farmers incentives to take their operations overseas. Some of them landed in Texas. Now several large Taiwanese farms dominate Texas's small shrimp farming industry. Most of the farms are just getting started. Seedstock is in short supply. Harlingen Shrimp Farms (formerly Laguna Madre Shrimp Farms), now owned by Taiwanese investors, operates a big hatchery, but it has its own ponds to stock and can't supply the entire industry during the brief stocking window in late spring. Hung's Shrimp Farm, Inc., a new farm, owns the Lone Star Hatchery, but this hatchery is brand new and not yet a consistent producer. Other hatcheries are under development. In 1992, many in the industry were working with disease-free seedstock and broodstock supplied by The Oceanic Institute in Hawaii. Like South Carolina, the trend in Texas is toward high-density farming--small ponds, tight management, aeration, high-quality feeds.

HAWAII

Shrimp farming has a long and colorful history in Hawaii. Before Captain Cook arrived in 1778, Hawaiians were gathering marine shrimp from coastal ponds that ringed the shores of all the islands. Modern shrimp farming got started in 1979, when the Japanese firm IKKO moved to Hawaii and leased 13 acres of ponds from the Lowe Aquafarm Company and established a hatchery at The Oceanic Institute. IKKO's goal was to use Japanese technology to produce the kuruma shrimp, *P. japonicus*, for live shipment to the Tokyo market.

From 1980 to 1983, the pilot-scale farm produced and exported shrimp. In 1982, during Golden Week (a Japanese holiday), IKKO received up to $40 a pound for its live shrimp. Nonetheless, IKKO closed the farm in 1983.

In the early 1980s, Marine Culture Enterprises (MCE), a cooperative venture between Coca Cola Company and the University of Arizona's Environmental Research Lab, moved its shrimp farming project from Mexico to Hawaii. In Mexico, MCE had developed super-intensive farming technology which utilized air-supported greenhouses, shallow raceways, high-quality feeds, and water exchange rates as high as 500 percent a day. After moving to Hawaii, MCE was sold to W.R. Grace, which opened its first production unit in 1984. After working out the kinks during the first two years, MCE was ready for its first big harvest in 1987. It was farming *P. stylirostris* which is particularly sensitive to IHHN virus. This virus swept through the farm like wildfire, destroying a million dollar crop. W.R. Grace saw this as too much risk and sold the farm to a Norwegian firm. Renamed Pacific Sea Farms, it is still active, but not in production.

Aquatic Farms, Ltd., was another early entry into Hawaiian shrimp farming. It operated a small shrimp farm on the windward side of Oahu and did consulting work. Today, Aquatic Farms is principally an international consulting firm. In the early 1980s, however, it developed techniques at the farm which were marketed overseas. Later, it sold the farm to the State of Hawaii, which renamed it the Mariculture Research and Training Center.

Amorient Aquafarm is the largest shrimp farm in Hawaii. At one facility it has 143, one-acre medium-density ponds, most of them producing *P. vannamei*, but some of them producing freshwater prawns, *Macrobrachium rosenbergii*, and some fish species. At another location, Amorient raises shrimp in small high-density ponds.

Amorient has developed a couple of innovative marketing approaches. It has a roadside stand next to the farm where tourists come by, see the farm in the background and buy cooked shrimp, fresh tails, shrimp cocktails, a shrimp plate, shrimp on a stick, and shrimp tempura. Amorient also invented the "Avon Ladies" of shrimp culture, an informal network of women who sell shrimp door-to-door in ethnic neighborhoods. The ladies pick up 50-100 pounds at drop off points and then sell it in their neighborhoods.

In March 1992, Amorient's hatchery announced the availability of commercial quantities of disease-free *P. vannamei* seedstock. Amorient has years of experience shipping live nauplii, postlarvae and broodstock around the world. Currently, it is expanding the hatchery so that additional supplies of disease-free seedstock and broodstock will be available in 1993.

The Oceanic Institute (OI), a private nonprofit marine research center that employs 100 people, began examining the technical and economic aspects of shrimp culture with support from the State of Hawaii in 1978. In 1984, OI became the coordinator of the Gulf Coast Research Laboratory Consortium, a USDA funded program designed to investigate the feasibility of shrimp farming in the United States. When the OI team looked at the economics of shrimp farming, it came to the conclusion that existing, medium-density technology would not be profitable in Hawaii. In 1987, OI developed an high-intensity, round pond system with a center drain to remove accumulated sediments. Paddlewheels aerate and circulate the water, creating a gentle whirlpool that sweeps sediments to the center of the pond where they can be drained away. Currently, OI produces disease-free broodstock and seedstock at a hatchery on the big island of Hawaii. In 1991 and 1992, this hatchery supplied disease-free broodstock and seedstock to many private sector shrimp farms and hatcheries in the United States. The Oceanic Institute also co-manages the Center for Tropical and Subtropical Aquaculture, one of five regional aquaculture centers established by the USDA.

This report was prepared by Bob Rosenberry, Editor/Publisher-*World Shrimp Farming*, in August 1992.

ENDNOTES

1. There are no known Canadian research institutes working on shrimp culture. Carolyn Walker, Markon Corporation, personal communications, July 6, 1992. Central American and Caribbean countries are included under Latin America.

2. See Dennis Weidner and Randolph Wells, "Puerto Rican Shrimp Culture," *International Fishery Reports* (IFR 92/53), July 24, 1992.

APPENDIX

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