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A SUSTAINABLE SHRIMP MARICULTURE INDUSTRY FOR ECUADOR

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International Coastal Resources Management Project

The University of Rhode Island

Shrimp Mariculture Development and Coastal Resources Management: Lessons from Asia and Latin America

Desarrollo de la Maricultura del Camarón y Manejo de Recursos Costeros: La Lección Aprendida de Asia y Latinoamérica.

Conner Bailey

Resumen

En Asia Oriental, la maricultura de camarones peneidos de Japón y Taiwan está basada en sistemas altamente intensivos. Los costos de producción en Japón son altos, alrededor de US\$25,50 por Kg, en Taiwan los costos son menores, unos US\$5,00 por Kg, que sin embargo son unas cinco veces mayores que los de Ecuador.

En Asia Sudeste hay una larga tradición en acuicultura y se están desarrollando varios proyectos de cultivo de camarones (Indonesia, Tailandia, Filipinas, Sri-Lanka, Malasia). En Tailandia un laboratorio privado produce 45 millones de postlarvas (pls) por año de <u>Penaeus monodon</u>. En el periódo de 1978-1981 el valor promedio de las exportaciones de camarón de Indonesia, Malasia, Singapur, Tailandia y Filipinas fue de US\$400 millones (50% corresponde a Indonesia). La producción esta ligada principalmente al mercado japonés pero hay gran interés de extenderse al mercado de Estados Unidos.

En el Sur de Asia hay sistemas extensivos de cultivo de camarón. India exportó 55.000 t.m. de camarón congelado a los Estados Unidos, con un valor de US\$275 millones. Los cultivos de camarón son alternados con los de arroz tolerante de altas salinidades. Bangladesh tiene en el camarón el segundo rubro de exportación.

El Banco Mundial y el Banco de Desarrollo Asiático han planificado programas de apoyo financiero para el cultivo del camarón en los países citados.

La maricultura del camarón en Latinoamérica difiere marcadamente de la asiática. Así, en Latinoamérica no hay una larga tradición en maricultura, constituyendo una nueva adaptación atractiva para la exportación. En Asia la mayor población reside en las partes costeras, con una alta explotación de los recursos, mientras que en Latinoamérica la población está concentrada en el interior, por ello el gran tamaño de las "granjas" camaroneras de Latinoamérica, en comparación con las asiáticas. Después de Ecuador, Brasil y México tienen el mayor potencial para desarrollar esta industria.

En Afríca se conoce que hay planes preliminares para la construcción de estanques en Madagascar y Kenya y que hay extensas áreas físicamente apropiadas para cultivos en Madagascar, Costa de Marfil, Benin, Gana, Nigeria y Kenya.

El documento presenta varias consideraciones respecto de la relación entre el buen estado del manglar y el desarrollo de la maricultura, basándose especialmente en trabajos realizados en el Sudeste de Asia y Panamá.

Analizando los aspectos sociales y económicos de la maricultura del camarón en el Ecuador, el autor señala la necesidad de considerar los efectos de este desarrollo en las comunidades que dependen tradicionalmente de los recursos costeros para su sustento, las cuales son generalmente política y económicamente marginales dentro de las sociedades nacionales. Quienes adoptan las políticas necesitan ser sensibles al impacto del desarrollo de la maricultura del camarón en el empleo, distribución de ingresos y en la nutrición, tanto para las comunidades locales como para la sociedad en general.

Las recomendaciones del autor se refieren a la necesidad de que las autoridades ecuatorianas reconozcan la existencia de problemas serios en el manejo de recursos costeros, originados en la conversión del manglar a estanques camaroneros, a la necesidad de una revisión de la distribución de beneficios, al desarrollo de estrategias de producción de bajo costo, incluyendo a productores de pequeña escala que tienen limitados recursos financieros y técnicos.

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Introduction

In less than two decades, shrimp mariculture has become a significant source of foreign exchange earnings for a small number of tropical developing countries. The rapid expansion of shrimp mariculture has also had a significant impact on coastal resource use in many countries. The purpose of this report is to review coastal resource management problems stemming from shrimp mariculture development in Asia and Latin America, and to assess the effectiveness of steps taken to mitigate these problems. The study is based on an extensive literature review and nine years of field experience in Southeast Asia. Approximately half of this time was spent studying coastal resource use and management in Malaysia, the Philippines and Indonesia.

This report was prepared with the assistance of Mr. Munirrudin Mullah, a fisheries biologist from India working on his doctorate in the Auburn University Department of Fisheries and Allied Aquacultures, and Mr. James Seger, a doctoral student in agricultural economics. The report itself is divided into four sections, beginning with an overview of tropical shrimp mariculture development. Following this is a discussion of coastal resource management problems associated with shrimp mariculture and the experience of several countries in dealing with these. Next comes a discussion of social issues surrounding shrimp mariculture development. Finally, a concluding section reviews key findings and presents a set of recommendations designed to help policymakers formulate sustainable development strategies.

Overview of Tropical Shrimp Mariculture Development

This section provides a descriptive summary of tropical shrimp mariculture developments in Asia, Latin America and Africa, and discusses future industry trends based on investor activity and government policy among countries in those regions. Regional and national comparisons on pond area, productivity and type of production systems are summarized in Table 1.

East Asia

Mariculture of penaeid shrimp in both Japan and Taiwan is based on highly intensive culture systems. In Japan the industry is geared to a small luxury market for live shrimp, and production costs are as high as U.S. \$25.50 per kilogram (kg) (Mock, 1983). Shrimp mariculture in Taiwan is less intensive and less costly, though at U.S. \$5.00 per kg, production costs are roughly five times that of Ecuador (Mock, 1983). Like Japan, Taiwan produces high quality shrimp for domestic markets, but high production costs are likely to limit Taiwan's role as a supplier in the international market for shrimp.

Although the Chinese aquaculture tradition is not limited to Taiwan, the focus of aquacultural development within the People's Republic of China has been on freshwater fish for domestic consumption, and not on shrimp mariculture. Considering mariculture generally, a United Nations Development Programme (UNDP) report concluded that "This is an area of aquaculture in which China is not very advanced," (UNDP, 1979:39).

The People's Republic of China is currently undergoing a major reorientation of its economic structure to encourage greater private initiative to increase foreign exchange earnings and speed modernization of its economy. The implications for shrimp mariculture are still unclear. It is known, however, that China has entered into a joint venture enterprise with a Japanese company (National Marine Fisheries Service, 1985a), and that a private company in China is soliciting a U.S. partner for a shrimp mariculture joint venture (NMFS, 1985c).

Southeast Asia

Like East Asia, Southeast Asia has a long-established aquaculture tradition. Coastal mariculture throughout the region can be described as an extensive polyculture of milkfish (*Chanos chanos*) and penaeid shrimp (primarily *Penaeus monodon* and *Penaeus merquiensis*). Until recently, ponds were stocked primarily through tidal action; and milkfish fry, shrimp postlarvae and other marine organisms were trapped and held until harvest. Low population densities, little if any pond fertilization, and the absence of supplemental feeding resulted in low yields as well as low production costs.

By the early 1970s, international stocking of both milkfish and penaeid shrimp had been introduced but was not yet common (Ling, 1973). Production was still oriented primarily towards milkfish production for domestic markets, though during the 1970s marine shrimp landings throughout the region tapered off amid mounting evidence of over-exploitation of demersal resources (Pauly, 1979). By the early 1980s, Southeast Asian governments and international donors had identified shrimp mariculture as a major growth industry and source of foreign exchange earnings.

Current estimates indicate that Southeast Asia has over 400,000 hectares (ha) of brackish water ponds in production using extensive polyculture systems. This total could double or even triple (Table 1), though such development is not likely to be as significant as efforts to achieve incremental improvements in the productivity of existing ponds.

The Asian Development Bank and the World Bank are currently supporting shrimp mariculture projects in Indonesia, Thailand, the Philippines, Sri Lanka, Malaysia and Bangladesh. Scura (1985) notes that these two multilateral donors are planning to commit more than U.S. \$200 million to development of Asian aquaculture. This level of investment in an already well-established industry could have a major impact on world markets. Although some of these projects will encourage adoption of semi-intensive production systems (see Villalon, this volume), it is likely that most Southeast Asian producers will continue to use an extensive culture system modified somewhat by low levels of artificial stocking and supplemental fertilization and/or feeding.

There are exceptions to this pattern. Thailand's shrimp mariculture industry includes a few large firms with inhouse hatcheries producing shrimp on a semi-intensive basis (American Embassy, Bangkok, 1986; Pedini, 1981). One large private hatchery producing 45 million *P. monodon* postlarvae per year is the recipient of a loan from the International Finance Corporation, a subsidiary of the World Bank. In Malaysia, the government is encouraging private sector investment in shrimp mariculture by granting "pioneer status," a 5-year tax holiday or investment credit of up to 100 percent, a subsidized loan program for producers, and an abatement of income subject to tax for exporters (American Embassy, Kuala Lumpur, 1986).

Southeast Asian nations are now major suppliers of shrimp to the international markets. During the period 1978-1981, the combined average annual value of shrimp exports from Indonesia, Malaysia, Singapore, Thailand and the Philippines was approximately U.S. \$400 million (Floyd, 1984). Indonesia alone accounted for roughly half of this figure. More recent data from the Food and Agriculture Organization (FAO) suggest that exports from this region increased during 1982 and 1983 (FAO, 1983).

Japan is the principal importer of Southeast Asian shrimp. The reasons for this have less to do with consumer preference for Asian species of penaeid shrimp than with linkages established through more generalized patterns of international trade. Japan is Asia's "economic colossus of the north," a fact reflected in volume of trade and frequency of sailings between Japan and tropical developing countries of Asia. Japan also has a long history of involvement in the fisheries of Asia that continues today in the form of joint venture enterprises which capture, process and export shrimp to Japan. Many independent shrimp exporters from Southeast Asia are also linked to Japanese buyers through credit obligations (Angell et al., 1985).

Although most shrimp producers in Asia are linked to Japan for the time being, there is considerable interest among producer nations in diversifying market outlets, including expanding sales to the United States. However, before producers are able to do this, they must overcome quality control problems. For example, Asian countries have had difficulty marketing in the United States because the Food and Drug Administration (FDA) has detected persistent problems with bacterial and other contamination. As a result, shrimp from the region often are very carefully tested before being released, resulting in expensive delays and frequent rejections (Bailey et al., 1985). Once these problems are overcome, there is no reason to expect that *P. monodon* and *P. merquiensis* will not achieve consumer acceptance in U.S. markets. *P. merquiensis* is a medium-sized white shrimp that U.S. consumers will find indistinguishable from *P. vannamei* and *P. stylirostris*. The larger tiger prawn (*P. monodon*) is more distinctive, but is already accepted by U.S. consumers in California (personal observation and interviews with retail outlets).

South Asia

India and Bangladesh have established shrimp mariculture industries based on extensive cultivation methods involving natural stocking through tidal action. Both countries appear poised to expand the area devoted to shrimp mariculture and to increase productivity through selective low-cost improvements.

India holds a long-established position as the world's leading exporter of high quality shrimp. In 1985, India exported over 55,000 metric tons (m.t.) of frozen shrimp valued at U.S. \$275 million (Marine Products Export Development Authority, 1986; see also the Newsletter of the The World Aquaculture Society, Vol. 17, No. 1, 1986, p. 6). This figure represents 86 percent of the total value of India's fisheries exports. Exports of diced and canned shrimp were insignificant, accounting for less than 0.1 percent of export value. Marine capture fisheries account for almost all export-quality shrimp.

Along both the east and west coasts of India, extensive shrimp mariculture is frequently rotated with salt-tolerant rice varieties grown in reclaimed coastal land. After the rice harvest, the sluice gates are opened to allow for natural stocking of fish and shrimp through tidal action. Large areas (in some cases several hundred hectares) are inundated at the same time. No supplemental feeding is used and management inputs are minimal. Minimal labor costs are incurred during harvest, when the fields are drained. Productivity per hectare is low and could be improved, but costs of production are extremely low.

India is in a position to maintain its leadership in shrimp export markets through mariculture development. Since the 1960s, when shrimp exports became a major growth industry, considerable research effort has been devoted to understanding the biology of major indigenous species (especially *P. monodon* and *P. indicus*). The goal of this research has been to develop simple technologies that require low input levels while improving yields and profits. The government is focusing most of its attention on developing small-scale shrimp mariculture operations. Farmers owning 5 hectares (ha) or less are eligible for low-interest loans to finance land acquisition or pond construction. Some programs include a subsidy of 25 percent to 33 percent for construction costs. A separate program is designed to provide working capital to small-scale producers.

Shrimp is Bangladesh's second most important export commodity (Kibria, 1985). The government of Bangladesh has identified shrimp mariculture as an important source of foreign exchange earnings and offers exporters a transferable permit to import goods up to 80 percent of the exported value (American Embassy, Dhaka, 1986). The production system resembles that of India. Both the World Bank and the Asian Development Bank are reported planning to provide financial assistance for shrimp mariculture development (Scura, 1985). Like India, Bangladesh will continue to base its shrimp mariculture on low-cost extensive production practices.

Sri Lanka is also developing a shrimp mariculture sector with the assistance of foreign investors (American and Taiwanese) and international development assistance (Asian Development Bank). Government incentives to the shrimp mariculture industry include a 5-year tax holiday on profits from exports, and income tax exemption for dividends paid to shareholders of qualified companies during this period (American Embassy, Colombo, 1986). Chamberlain (1985c) reports that there are already two operational hatcheries. The American Embassy in Colombo (1986) reports that one of these hatcheries was established as an experimental facility to develop hatchery feeds.

Latin America

Shrimp mariculture in Latin America differs markedly from that in Asia. In Latin America, coastal mariculture is a new adaptation made attractive by export markets. Export opportunities clearly are an important spur to continued development in Asia, but this expansion will build on a long tradition of mariculture experience. Also, in most parts of Asia, a high proportion of the population lives in coastal areas, and coastal resources tend to be highly exploited. In contrast, in most of Latin America, the population is concentrated in the interior, and coastal resources are generally less heavily exploited. These differences contribute to the relatively large size of individual Latin American mariculture farms compared to those in Asia. The scale of mariculture operations in Latin America is consistent with the latifundia (estate) tradition of large holdings in much of the region's agricultural sector.

Table 2 shows an estimate of projected shrimp mariculture production in Latin America by 1990. Ecuador is expected to remain the dominant producer in the region, but other nations will begin to compete for market shares. After Ecuador, Brazil and Mexico are the countries with the greatest long-term potential for shrimp mariculture. Mock (1982) reports that a solid research infrastructure has been established to support development in Brazil. Scott (1985) notes that the Brazilian government is willing to provide a variety of incentives to attract investors. Scott also reports that Brazil has a number of well-established hatcheries and is likely to be self-sufficient in hatchery-produced postlarvae. He notes that the high cost of feed is the single most important factor constraining growth.

Mexico may have greater potential for development of shrimp mariculture than Table 2 suggests, though national economic problems may slow growth in the short term. Under current law, all development of shrimp fisheries, including shrimp mariculture, are activities reserved for cooperatives and not private farms. Under these conditions, it is likely that the current extensive system of shrimp mariculture (practiced by closing off lagoons) will continue as the dominant production system.

Africa

Shrimp mariculture has yet to become an established industry in any African nation. Coastal aquaculture is a traditional enterprise in many countries and includes the use of earthen ponds and brush parks in lagoons (Coche, 1982). Many species are grown, mostly finfish for domestic consumers, and production is largely based on extensive methods.

Ardill (1982) notes that preliminary plans are being made to construct shrimp ponds in Madagascar (200 ha) and Kenya (50 ha). Extensive areas in several nations (Madagascar, Ivory Coast, Benin, Ghana, Nigeria, and Kenya) are physically suited to shrimp mariculture, and competing land uses may not be as great as elsewhere in tropical developing countries. Despite this potential, however, it is difficult to imagine African shrimp producers having a significant impact on world markets in the foreseeable future.

Summary

In 1983, the United States passed Japan as the world's leading importer of shrimp, though Japan still remains the leader in terms of total import value and per capita consumption (Rackowe, 1984). The United States and Japan together consume approximately two-thirds of the total world shrimp exports. Rackowe (1983) estimated that by 1990, additional supplies produced by shrimp mariculture would begin having a significant impact on world markets. Indeed, it is clear that this impact is already being felt in the United States and is having the effect of holding down prices (Prochaska and Keithly, 1984). This is, then, a very good time for Ecuador to take stock of her shrimp mariculture industry and determine future development directions.

The above review of shrimp mariculture development indicates significant investment in this industry in Asia and Latin America. Table 3 contains data comparing estimated 1986 shrimp mariculture production with projected production in the year 2000, suggesting that by the turn of this century harvests of cultivated shrimp will more than double.

Management of Physical and Biological Resources

Throughout the tropics, industrialization, urbanization, increased use of agricultural chemicals, and other consequences of economic development have resulted in widespread environmental stress and degradation. Coastal areas in particular have been greatly affected because (1) they are the downstream recipient of organic and inorganic pollutants and (2) development is often most pronounced in the coastal zone. Many coastal resource management problems are attributable to a narrow sectorial approach to development planning and the consequent failure to recognize environmental linkages and potential adverse effects. For example, soil erosion caused by opening new land for agricultural production may result in excessive sedimentation in coastal wetlands. Runoff from agricultural chemicals may affect water quality and negatively affect shrimp mariculture. Conversion of coastal wetlands to other uses (e.g. mariculture or agricultural production) also affects habitats of other valuable marine species. Urban and industrial pollutants, and untreated domestic sewage) all reduce environmental carrying capacity and preclude

certain development options, including mariculture. To the extent that natural resources are destroyed or degraded, future development opportunities are limited or foreclosed.

Mangrove Habitat

Mangroves provide structure and stability in an otherwise featureless and fluid zone. Mangroves are highly complex and productive ecosystems that serve a wide variety of useful functions including prevention of coastal erosion and encouraging soil deposition, provision of food, shelter, and sanctuary for birds and mammals, as well as spawning, nursery and forage areas for numerous finfish, crustacean, and mollusc species. Mangroves also provide a source of building materials, food, firewood, charcoal and other products for local human populations.

In most humid tropical regions where mangroves exist, local populations have historically utilized the resources found therein for a variety of purposes (Bailey, 1983; Hamilton and Snedaker, 1984; Peterson and Schmittou, 1985; Snedaker et al., 1986). Despite the intensity with which local populations have exploited mangrove resources, national and international development policymakers traditionally regarded mangroves as wastelands that contributed little to national development. Inadequate knowledge and appreciation of the value of mangrove resources may explain past actions which resulted in massive destruction of mangrove for timber, land reclamation (for agricultural or other purposes), or conversion to shrimp ponds. Today, however, scientific evidence makes it clear that healthy mangroves and other coastal ecosystems are vital to sustainable coastal development.

Those concerned with sustainable development of shrimp mariculture have particular cause for concern regarding destruction of mangrove habitat. Despite efforts in most major shrimp-producing nations to establish hatcheries, postlarvae captured in the wild are likely to remain the most important stocking source for the foreseeable future. Convincing evidence exists that mangroves are critically important habitat for shrimp in the postlarval and juvenile stages of their life cycle (Prahl, 1978; Martosubroto and Naamin, 1977; Turner, 1977, 1985, 1986). Continued destruction of mangrove habitat is likely to exacerbate existing postlarvae shortages, the primary constraint to increased shrimp mariculture production in many countries, which until recently included Ecuador.

Southeast Asian Mangroves

Throughout Southeast Asia, coastal resources are under heavy pressure. As a region with a strong maritime tradition, the coastal zone has always supported relatively large populations. Over the past several decades, the relative proportion of the population living within a short distance of the sea has increased. Many landless agricultural workers and others seeking to improve their fortunes have moved to the coast, where access to important natural resources is not restricted by private ownership. In general, "open access" characterizes both mangroves and inshore fishing grounds.

Given long-standing familiarity with coastal resources and the growing importance of these resources, we might expect Southeast Asian nations to have well-established resource management programs in place. However, such is not the case, though over the past decade most countries have attempted to establish such programs. These efforts are reviewed below to identify common achievements and constraints.

The Philippines

Brackish water ponds in the Philippines were established primarily to grow milkfish (*Chanos* chanos), with harvests of penaeid shrimp an incidental bonus. Existing ponds were developed almost exclusively from mangrove areas, and any further expansion will be at the expense of mangrove forests (Peterson and Schmittou, 1985). Siddall (1985) notes that prior to the 1970s, mangroves were considered to have little value in the Philippines and permits to convert mangrove into brackish water ponds typically received *pro forma* approval. During the period 1952-1972, brackish water ponds more than doubled in area from 88,681 hectares (ha) to 174,101 ha (Peterson and Schmittou, 1985).

During the early 1970s, preliminary scientific evidence (e.g., Odum, 1972) indicated that mangrove ecosystems were highly productive and supported a wide range of economically important activities, including commercial fisheries for shrimp and other valuable marine organisms. A series of restrictions were imposed during the 1970s and, in the next 10 years, the conversion of mangrove in the Philippines slowed dramatically; between 1972 and 1982, only 2,130 ha of new ponds were created (Peterson and Schmittou, 1985). During this time mangroves became a public trust to be administered jointly by the Bureau of Forest Development (BFD) and the Bureau of Fisheries and Aquatic Resources (BFAR). Both BFD and BFAR are agencies of the Ministry of Natural Resources (MNR). Current regulations stipulate that approval to convert mangrove into fishponds must first be obtained from the BFD, which then turns administrative control over to the BFAR. Final approval for development is granted by the MNR. Leases are granted for 25-year terms and may be renewed for an additional 25-year period. Lessees are given 5 years to develop their holdings or forfeit their leases. Regulations also stipulate that no ponds may be within 40-meter strips along rivers and other inland waters, and 100-meter strips facing bays and the sea. The purpose of this greenbelt is to preserve important features of the mangrove habitat which are of particular value to wild populations of shrimp and other marine organisms. The assumption is that shrimp postlarvae and juveniles seek shelter and food along the fringe of mangrove forests and are less dependent on the condition of mangroves further inland. This action was meant to strike a balance between mariculture development and habitat preservation, which also appears to be the case with a regulation that requires lessees to plant trees within at least 20 meters of the edge of tidal streams.

Siddall (1985) reports that the effectiveness of these measures has suffered due to administrative weaknesses within the BFD and the BFAR. When examining resource management issues in the Philippines, it is necessary to realize that well-meaning policies established at the national level often have little effect on what happens at the provincial or sub-provincial levels. From personal experience in the Philippines, the author suggests that a primary cause of "administrative weakness" is corruption. It remains to be seen when or if the administration of President Aquino will be able to overcome this problem.

Indonesia

Like the Philippines, brackish water aquaculture in Indonesia is well established and based on extensive polyculture of milkfish and shrimp. Much of the existing area devoted to aquaculture was originally in mangrove, and most opportunities for future expansion of pond area are found in mangrove areas. The best estimate is that Indonesia has approximately 3.8 million ha of mangrove, more than any other nation (Burbridge and Koesobiono, 1982). Over half of this total (2.9 million hectares) is located on the Indonesian portion of New Guinea (Irian Jaya). Sumatra and Kalimantan also have extensive mangrove forests. However, the potential for aquaculture development in the huge mangrove forests of Indonesia is limited. A large portion of this area is found in very remote locations where human populations are sparse and the necessary supportive infrastructure (roads, electricity, ports, etc.) does not exist.

The Indonesian government is planning to expand brackish water pond construction, primarily within those areas where this industry is already well established. During the current Fourth Five Year Plan (1983/84 to 1988/89), government plans include opening 100,000 ha of new brackish water ponds for shrimp mariculture and intensifying production on 120,000 of the existing 194,000 ha (Republic of Indonesia, 1983). Some designated areas appear to be unsuitable for establishing new ponds (Burbridge and Maragos, 1985), but there is little doubt that Indonesia is committed to expanding shrimp mariculture.

In Indonesia, as in the Philippines and many other countries, the key constraint to establishing integrated and sustainable development strategies is the sectorial approach of government agencies (e.g. forestry, agriculture, fisheries) which appear unable or unwilling to consider the multi-use/multi-user nature of most coastal resources. Individual agencies approach coastal resource management and development with prejudices that limit their purview to those issues directly related to agency jurisdiction and goals.

For example, jurisdiction over mangrove forests is divided between government agencies separately responsible for fisheries and forestry. The Ministry of Forestry and the Directorate General of Fisheries (DGF) agree that there should be a greenbelt of mangrove, but disagree on the dimensions of the protected area. The Ministry of Forestry argues that a 50-meter greenbelt is sufficient to protect fisheries interests, and claims exclusive jurisdiction over all else. The DGF argues that a 400-meter greenbelt is necessary.

In a review of Indonesian coastal resource management, Burbridge (1983) examined the uniform greenbelt concept and found it seriously flawed as a management tool because it ignored qualitative differences between mangroves and so failed to safeguard the multiple-use qualities of this resource. He

called for a more flexible approach to defining mangrove management units that would protect estuarine and deltaic mangrove areas crucial to fisheries production, and still permit firewood collection or the harvest of other valuable forest resources by local residents. His preliminary analysis of the value of mangrove for sustained development suggested that the fishery value may be greater than the forestry value, and that conversion of mangrove to brackish water ponds would be detrimental to sustainable coastal and estuarine fisheries production.

Development takes priority over resource conservation and management in policies affecting mangrove and other tidally influenced swamp lands, which support not only shrimp mariculture development, but also programs of land reclamation for agricultural purposes. Vast areas have been drained for rice cultivation under government-sponsored transmigration schemes. In many cases, these lands are agriculturally marginal and it is not certain that their use for agriculture can be sustained (Burbridge and Maragos, 1985). Acid sulphate soil conditions are frequently encountered. No adequate studies have been made regarding the impact of this development on related ecosystems, including estuarine and coastal fisheries. Burbridge and Maragos (1985:78) conclude "as a result of the failure to coordinate and integrate development policies and to regulate the exploitation of coastal resources, the ability of coastal resource systems to sustain development is being eroded." Balanced against these pro-development influences are a number of senior Indonesian government officials who are aware of the need to see beyond sectorial and agency boundaries and promote environmentally sustainable forms of development. The Ministry of Population and the Environment (MPE), for example, is unlike other ministries in that it represents no sectorial interests. Rather, it acts as a cross-sectorial coordinating ministry, and has the authority to bring together different ministries to promote coordination of their activities.

The MPE has a small staff, limited budgetary resources, and no significant presence outside the capital. To be effective, it must rely on its powers of persuasion and to be persuasive, the MPE needs access to independent sources of information. Therefore, the MPE sponsored and supported the establishment of Environmental Study Units at major regional universities throughout Indonesia. The Units are commissioned to conduct studies that inventory local resources and assess management needs.

The key element in the MPE's achieving a degree of success has been the personal influence of the agency's leader on the President and on his fellow ministers (Burbridge and Maragos, 1985). This means that the environmental conscience of the Indonesian government remains personalized rather than institutionalized. Nonetheless, creation of the MPE represents a recognition the part of some Indonesian leaders that development of natural resources is too important to be left to narrow sectorial interests.

Mangrove Management in Panama

Siddall (1985) notes that shrimp mariculture in Panama has had relatively little negative impact on mangrove, compared with the Philippines and Ecuador, because Panama has clear administrative jurisdictions, adequate information for management purposes, and semi-intensive rather than extensive shrimp mariculture production systems.

Unlike in either the Philippines or Ecuador, a single agency (the Direccion General de Recursos Renovables, or RENARE) has responsibility for protection of mangrove forests in Panama. RENARE appears to have adopted a clear conservationist posture (e.g., prohibiting the exploitation of red mangrove for its bark until a careful assessment could be made of the impact of this practice).

RENARE has also shown a willingness to enforce their regulations, fining shrimp farmers whose ponds encroached on mangrove. Monitoring the impact of pond construction is done by comparing aerial photos taken prior to and after pond construction. The Direccion Nacional de Acuacultura has cooperated with RENARE, encouraging potential investors to establish ponds in salt flats by publicizing the risks of acid sulfate soils and high construction costs associated with establishing shrimp ponds in mangrove areas. Because adequate salt flats were available to meet the need of new investors, pressure on mangrove resources was much reduced.

Finally, the adoption of semi-intensive production methods drastically reduced the amount of land necessary for shrimp mariculture. The primary influence behind adoption of this system appears to be the presence of Ralston-Purina, which introduced shrimp farming to Panama. Subsequent investors attempted to replicate successful techniques developed by Ralston-Purina rather than the extensive methods employed in Ecuador and the Philippines.

Management of Wild Shrimp Populations

With few exceptions, shrimp mariculture development is occurring where wild populations of penaeid shrimp exist and are exploited for export markets. In most cases, shrimp exports derived from capture fisheries far outweigh those generated by culture systems. Because most marine shrimp populations are under heavy pressure, management of fishing effort is a matter of concern to most governments.

Although Ecuador has a large shrimp mariculture industry, its wild stocks are also under heavy fishing pressure, both from the trawl fishery and from the artisanal fishery for postlarvae. Unusual climatic conditions associated with El Niño in 1983 and low sea temperatures in the Gulf of Guayaquil during 1984 also appear to have affected wild shrimp populations. Concern about resource depletion has led to a seasonal closure both for shrimp trawling and the harvesting of postlarvae.

McPadden (1984:44) notes that, although Ecuador's capture fishery for shrimp is overcapitalized and appears to have experienced declining catch per unit effort ratios over the past twenty years, there is little evidence of decreased landings due to overfishing. In Ecuador, the primary factor which led to the seasonal closure on offshore trawling and harvest of shrimp postlarvae was concern about adequate supplies for stocking ponds.

Within the foreseeable future, shrimp mariculture development in Ecuador and in most other tropical developing countries will depend upon wild marine shrimp populations for stocking materials, either as postlarvae or as gravid females, to produce postlarvae in hatcheries (Mark D. Leslie, Hatchery Manager, AQUA CAB, S.A., Guayaquil, personal communication). Thus, management of marine shrimp stocks will be guided increasingly by the two aims of ensuring sustainable harvests from the sea and ensuring an adequate supply of postlarvae for stocking.

Managing Marine Shrimp Fisheries

Between 1980 and 1983, the government of Indonesia imposed a ban on virtually all trawling (Bailey, 1987). Indonesian trawlers were small by Ecuadorian standards, displacing on average 20-30 gross tons. The boats were wooden-hulled and powered by diesel engines generating 135-200 h.p.

Trawlers were first introduced to Indonesia in 1966. Within 11 years their numbers had grown to over 3,000, mostly concentrated along the Malacca Straits and off the north and south coasts of Java. Data on Indonesia's demersal fisheries resources have been reviewed by Dwiponggo (1987). His analysis clearly indicates that during the period 1975-1979, each of these three centers of trawler activity experienced levels of demersal fishing effort beyond that necessary to achieve maximum sustainable yields.

Besides official concern about resource depletion, the government was forced to take action because of the negative impact of trawlers on the incomes of small-scale fishermen. There are nearly 1 million small-scale fishermen in Indonesia, approximately 40 percent of whom operate in the three areas identified above as the centers of trawling activity. The far greater fishing power of trawlers placed small-scale fishermen at a serious disadvantage in competing for a limited and often dwindling resource. During the 1970s, as ever greater numbers of trawlers began encroaching on what they regarded as their traditional fishing grounds, small-scale fishermen responded with violence to protect their livelihoods.

Competition and conflict between trawlers and small-scale fishermen, combined with mounting evidence of resource depletion, spurred fisheries policymakers to impose restrictions on trawler operations. For the most part, these regulations specified use of larger mesh sizes, limited the numbers of trawlers and sought to keep trawlers from operating in coastal waters.

In practice, however, these regulations proved difficult to enforce and were, therefore, ignored. The primary constraints to adequate enforcement include lack of clear enforcement responsibilities among government agencies, and inadequate personnel and patrol craft. Furthermore, enforcement problems were increased by political influence of trawler owners and by corruption (Bailey, 1987).

Evidence of continued illegal operations, and increasingly violent conflict between fishermen led to the proclamation of Presidential Decree No. 39 in 1980 banning all trawlers from waters off Java, Sumatra and Bali. In 1983, this ban was extended nationwide, with the exception of the Arafura Sea, where an industrial-scale fishery operates in joint-venture enterprises with Japanese partners. For a short while, the initial ban on trawlers led to declining harvests. But by 1982, landings of demersal species along the north coast of Java surpassed those preceding the trawler ban (Bailey, 1987). During this period, the number of fishermen in this area increased by 10 percent and average household incomes among small-scale fishermen increased by 30 percent (ibid.).

The impact of the trawler ban on shrimp exports was less serious than initially expected. Prior to 1980, trawlers had accounted for the bulk of all shrimp exports. The quantity of shrimp exports did decline between 1980 and 1983, but foreign exchange earnings increased by 15 percent, due in part to improved product quality. Unlike the shrimp landed by trawlers, most of which had been on ice for several days, small-scale fishermen land their catch every day (Dudley and Tampubolon, 1985). Once logistical problems were overcome, shrimp processors successfully adapted to obtaining supplies from small-scale fishermen and from brackish water pond operators, who had previously been ignored by most exporters content to have shrimp virtually delivered to their door by trawler fisherman.

One advantage of total ban on all trawling is that it is relatively easy to enforce compared with regulations which restrict trawlers from operating within a certain distance from shore or from using nets below a certain mesh size. Regulations of this sort have been attempted in numerous countries with little success due to ineffective enforcement (Garcia, 1986). Like total bans, seasonal closures are relatively easy to enforce, though identifying the optimal period for closure in the context of a multispecies fishery requires detailed information on population dynamics, including the spawning habits and life cycles of the most important species.

Managing Fisheries for Postlarvae and Gravid Female Shrimp

Despite concentrated efforts to develop hatcheries, shrimp farmers in Ecuador and most other major producing nations continue to depend on the harvest of postlarvae from the wild to provide stocking materials for their ponds. Moreover, those hatcheries which have not yet established closed-cycle systems continue to depend on the capture of gravid females for spawning. Within the foreseeable future, shrimp mariculture development will continue to depend on the harnessing of the reproductive energies of wild shrimp populations.

It is surprising that little attention has been devoted to management of directed fisheries for postlarvae and gravid females. The exceptions to this pattern appear to be Ecuador and Panama. In Ecuador, a seasonal closure on postlarvae has been imposed for the months of June and July (the season of peak postlarvae abundance is November-March). The offshore fishery for adult shrimp is closed during this period and also during January. There is no closed season for gravid females per se. In Panama, it is reported that some fishermen have discovered a means of locating gravid females which are then captured and sold to private hatcheries (P. Maugle, personal communication). Concern that such exploitation may have a serious impact on marine shrimp populations led to an area-specific ban on fishing for gravid females in Panama in 1976.

However, there may be good reasons why other nations appear not to share these concerns over directed fisheries for postlarvae and gravid females. In countries with long coastlines, such as India, Indonesia and the Philippines, wild shrimp populations are widely distributed rather than relatively concentrated, as they are in Ecuador and Panama. In Indonesia and the Philippines, postlarvae are harvested in areas at great distance from mariculture sites and shipped overland or sometimes by air in oxygenated plastic bags packed in cardboard boxes. Thus, the fishing effort for postlarvae is not concentrated in any one location or even one region. Also, the use of artificial stocking is not yet widespread and, where employed, generally does not involve the same level of stocking density. Thus, pressure on shrimp populations at the postlarval stage is not only dispersed, but is also less intense.

This is not to say that postlarval fisheries are totally unregulated. In the Philippines, local municipal governments leased out postlarval fisheries and milkfish fry fisheries to the highest bidder, though this system is designed to generate local revenues, not control levels of fishing effort (Smith and Panayotou, 1984). The fishery is open and numerous individuals (and often whole families) take part in this seasonal activity. What the concessionaires obtain is the right to act as sole buyer for postlarvae and fry caught within their area. A complex market for milkfish fry is well established in the Philippines and, in 1974, efficiently moved 1.35 billion fry from coastal waters through a variety of middlemen and on to growout ponds and pens (Smith, 1981). These well-established networks also serve to move shrimp postlarvae. Similarly complex and efficient networks exist in Indonesia (personal observations).

No information is available regarding limits placed on fisheries for gravid females except in Panama. Gravid females appear to be incidental to the overall shrimp catch of trawlers and other demersal fishing gear, though it is entirely possible that some trawler operators target gravid females. Mock (1983) reports that gravid *P. monodon* are shipped from Malaysia to hatcheries in Taiwan. Virtually all hatcheries in the region depend on gravid females caught in the wild, however, the number of hatcheries remains quite small and the level of fishing effort which they support appears not to have created concern.

Social Issues in Shrimp Mariculture Development

Shrimp mariculture has transformed the coastal ecology of Ecuador and brought about significant economic development. Whenever a significant form of socio-economic change occurs, some individuals are more likely to benefit than others. In the case of a new economic opportunity brought about by technological innovation, age, education and economic class often influence adoption behavior. Further, these variables are often associated with access to institutional resources (e.g., banks, government agencies) within a society, the kinds of contacts that often are crucial to economic success.

Having the right contacts may be particularly important in the context of natural resource development. As a starting point, let us consider a few propositions that combine the concepts of resource management and resource allocation:

- Natural resources are limited.
- Biologically renewable resources are finite but can sustain harvest over an infinite period of time if carefully managed.
- Management of limited resources is an inherently political process which entails conscious allocational decisions.

The first proposition is self-evident, though it does not address the crucial issue of dimensions: *how limited?* In the context of shrimp mariculture, the necessary resources include coastal land with appropriate physical characteristics and good water quality. In Ecuador, these limits are being approached (McPadden, 1984; Parodi, 1985).

In itself, the second proposition should excite little controversy. Let us, then, consider mangrove forests as a biologically renewable resource, capable of sustaining harvests of products useful to a society over an infinite period of time. In most tropical developing countries, mangrove forests have traditionally been heavily exploited on a sustainable basis by local residents for a wide variety of purposes.

This leads to the third proposition, which links resource management and the political process of resource allocation. The process of shrimp mariculture development transforms a multi-use/multi-user coastal resource into a privately owned single-purpose resource.

The existence or absence of property rights over coastal resources is itself a matter of fundamental importance in conceptualizing the policy implications of shrimp mariculture development. In most countries, including Ecuador, the state has established claim to coastal resources, which provides legal justification for allocating access to these resources. The alienation of publicly owned mangrove forests for shrimp pond construction is a good example of this allocation process.

In many tropical developing countries, mangrove forests are heavily utilized by local residents who have traditionally used available resources to meet needs for cash and household sustenance. Communities of people who depend on such coastal resources tend to be politically and economically marginal within the national society so it is not surprising that what they regard as their traditional rights to local resources is unknown or ignored by the larger society (Collier, 1978). This only becomes a problem when the resource in question becomes valuable as, for example, is the case with coastal mangroves deemed suitable for shrimp pond construction, logging or other uses.

The primary motivations for expropriating resources over which locals have traditional use rights are foreign exchange earnings and profits; the primary measures used to assess the feasibility of development are technical and financial. Smith and Pestanno-Smith (1985, see also Smith, 1984) argue that a wider range of variables should be addressed to assess the "social feasibility" of development. As used by these authors, social feasibility is a broad concept which refers to all aspects of development except those which are technical and financial. This concept brings to the forefront of consideration socio-economic, socio-cultural, legal, political, and institutional dimensions of development.

If development is a process through which improvements are made to the quality of life for society as a whole, rather than for certain classes or groups, these issues must be addressed. In particular, policymakers need to be sensitive to the impact of shrimp mariculture development on employment, income distribution, and nutrition--both within local communities and within society as a whole. For example, since many species of finfish, crustaceans and molluscs are dependent upon mangrove and other coastal wetlands for critical periods in their life cycles, massive mangrove conversion threatens the sustainability of marine harvests, the livelihoods of many local fishermen and others who depend directly or

indirectly on mangrove resources, and the primary source of protein for large numbers of people who cannot afford meat or other more expensive protein sources.

Shrimp mariculture is profitable, but the profits usually are not earned by those whose interests are threatened and whose immediate needs are income and employment. Shrimp farming does generate some employment, but the industry cannot be viewed as labor-intensive considering the small number of people employed per areal unit of production, or the limited employment generated per unit of capital investment. Most of those who find jobs are hired as unskilled laborers and guards, and wage rates for unskilled workers in coastal communities tend to be low, reflecting the opportunity cost of labor. The irony is that the very process of shrimp mariculture development contributes directly to low wages by reducing local opportunities through conversion of open access multiple use resources into privately owned property.

These negative consequences of development are not the blind chances of a cruel economic fate, but rather are the direct result of structural inequalities of wealth and power within certain developing nations. The issues are clearly put by Smith and Pestanno-Smith (1985:7):

"The vast majority of residents in coastal communities are desperately poor. They are poor because of their lack of access to alternative employment opportunities and because existing community and national structures and institutions often allow local elites to capture the bulk of any benefits that come from more productive technologies introduced to or adopted by such communities. Large-scale aquaculture enterprises frequently displace small-scale fishermen and aquaculturists through subsidized financing and institutional arrangements that favor the large-scale or corporate investor."

An important example of "institutional arrangements" favoring well-connected investors is the question of property rights. Coastal residents often regard mangrove and other coastal resources as common property of the community, legitimated by historic use and traditional rights. However, governments generally do not recognize these rights and claim the authority to grant long-term leases to those who have the financial means to develop significant aquaculture and other enterprises.

Conclusions

The purpose of the foregoing review was to identify coastal resource management issues posed by shrimp mariculture development, and to assess the experience of tropical developing countries in mitigating adverse social and environmental consequences of this development. Unfortunately, few serious management initiatives have been taken in these countries. The Philippines appear to be a partial exception to this finding, but in most countries, the profitability and foreign exchange earnings potential of shrimp mariculture are so strongly attractive to private investors and government policy makers alike that issues of resource management have been given little attention in the headlong rush to develop local shrimp mariculture industries.

Thus, the major findings of this study--which was to review resource management initiatives that might be adapted to Ecuadorian conditions--is that many nations are striving to repeat Ecuador's development successes and, therefore, seem destined to experience many of Ecuador's coastal resource management problems. There are, nonetheless, important messages herein for Ecuadorian policy makers concerned with sustainable development.

The first message is that the era of rapid growth is over. This is so, not only because Ecuador is approaching limits to the area that can be brought into shrimp production, but also because major increases in production elsewhere are likely to hold down world market prices, especially for the medium-sized shrimp most commonly produced in ponds.

Further, Ecuadorian producers are going to experience an erosion in profitability as low-cost Asian producers become more prominent in world markets. Ecuador's shrimp mariculture industry has prospered because production costs have been far below that of the alternate source (i.e., Gulf of Mexico shrimp trawlers) in their primary market (the United States). Asian producers are likely to prosper at the expense of Ecuadorians for the same reason.

Most producers in South and Southeast Asia are small-scale operators using minimal inputs in an extensive culture system. Although their productivity will remain low, in most cases costs of production

will be negligible. Net income per hectare under these conditions also may be low, but given limited alternatives for investment and employment, this is not likely to discourage producers from continued involvement in the industry. Low rates of return on investment, labor and management simply reflects the common level of opportunity costs for these items among small-scale producers in most tropical Asian countries.

Compared with small-scale Asian producers using minimal inputs, many Ecuadorian shrimp farmers could be regarded as high-cost producers. Moreover, these small-scale Asian producers are more likely than their Ecuadorian counterparts to continue producing shrimp even if the bottom drops out of the world market. Ecuadorian shrimp farmers generally are commercially oriented entrepreneurs sensitive to opportunity costs, especially those for capital and management. Asian producers are no less rational, but operate on the basis of wholly different sets of economic criteria which emphasize risk minimization and diversification of production activities.

Meltzoff and LiPuma (1985) suggest that Ecuadorian entrepreneurs have relatively short planning horizons and are likely to move into an enterprise which offers potential for quick profits, and then pull out once these opportunities are reduced. By contrast, Asian mariculturists have been in "business" for thousands of years. In Ecuador, shrimp are but the most recent commodity of a string which began with cacao and until recently was represented by the "yellow gold" of bananas (Delavaud, 1980). Given this perspective of history, what is the likely staying power of Ecuador's shrimp mariculture industry in the face of low-cost Asian producers?

History is not destiny, but in this competitive context, Ecuador's industry leaders and government officials clearly should consider with caution the economic feasibility of anticipated technological innovations which will alter the structure of production costs within the industry. For example, there is no question that more shrimp per hectare can be grown over the course of a year by improvements in pond design (e.g., establishing separate nursery ponds), increasing stocking density, and increasing supplemental feeding. It must be recognized that these measures not only increase input costs, they create dependencies on inputs, and input prices are beyond the control of individual producers or even the shrimp industry as a whole.

Input suppliers (e.g., feed mills) may be in a position to increase prices to the point where they capture most of the industry's profits. Consider the interest of feed suppliers in developing shrimp mariculture. Ralston-Purina established the industry in Panama as a means of developing demand for its primary product line, and subsequently sold its successful hatchery and grow-out operations. In Sri Lanka, the first business to invest in shrimp mariculture was a company primarily concerned with formulating feeds for hatcheries, not the production of postlarvae (American Embassy, Colombo, 1986). In the Philippines, San Miguel Corporation, the nation's largest corporation, is involved in shrimp mariculture development primarily to promote its line of feeds.

These companies realize that the greatest long-term profit potential in any industry dependent on supplemental feeding is in the supply of these feeds. As the world market for shrimp matures, the squeeze of rising costs and falling prices will affect the profits of individual producers far more than those of feed mills and other input suppliers.

If farm-gate shrimp prices fail to keep abreast of input costs, a natural tendency of individual producers will be to increase production to maintain income. This strategy leads to increased supply and continued downward pressure on prices. Intensifying production may be a rational action by individual producers, but for the shrimp mariculture industry as a whole it may lead to serious economic difficulties. Development in this direction is likely to promote the kinds of structural changes that will make the shrimp mariculture industry of Ecuador vulnerable to low-cost international competitors.

There are serious implications in this for coastal resource management. If intensification is not an alternative, the only means of increasing production is through extensification; that is, the opening of new areas for shrimp farming. This tendency should be resisted. The construction of new ponds, were this permitted, is possible only through conversion of mangrove. In an Ecuadorian version of Hardin's (1962) "Tragedy of the Commons," the conversion of mangrove may be rational for individual producers, but the negative impact on the industry could be serious, if not catastrophic, for the simple reason that less mangrove probably translates into reduced postlarvae supply. It is unlikely that hatchery development will reduce the need for postlarvae caught in the wild.

Recommendations

Ecuadorian policymakers are to be commended for recognizing the existence of a serious coastal resource management problem posed by uncontrolled conversion of mangrove to shrimp ponds, and for acting to halt the conversion process. Seasonal closures affecting offshore shrimp trawling and inshore harvest of postlarvae are further indications of official concern. Below are recommendations addressing a unique set of issues.

Resource Use Conflicts: A Research Agenda

Shrimp mariculture frequently involves the conversion of mangrove, a multiple use resource. Insufficient information exists to establish the tradeoffs involved either qualitatively (who is being affected) or quantitatively (how much is being gained or lost). In most parts of Asia, the multiple use quality of coastal resources is chiefly responsible for the concentration of population in the coastal zone, and it is this feature that provides the greatest hope for sustainable development. Future research should assess the possibility that development options within Ecuador are being foreclosed by current patterns of resource exploitation.

Policy Review: Distribution of Benefits

If Ecuadorian policy makers are to play a role in shaping the future course of their nation's shrimp mariculture industry, they need to know the impact of past development on employment generation, income distribution and nutritional status of the population. They need to establish goals for the future which specifically address these and other issues, including optimal scale of shrimp farming enterprises. This policy review should build on information collected when examining resource use conflicts.

Develop Low-Cost Production Strategies

Efforts should be made to focus biological and technical research on cost-minimization rather than on production-maximization so Ecuador's shrimp mariculture industry can remain competitive with Asian producers. These low-cost production technologies may emphasize greater reliance on locally abundant inputs, including labor. Extension personnel should be trained in low-cost technologies, which may be particularly well suited to small-scale producers with limited technical or financial resources.

	HA. IN PRODUCTION		YIELD		
REGION/COUNTRY	Current	Potential	kg/ha/yr	CULTURE SYSTEM	
ASIA					
INDIA	30,000 ^a	2,000,000 ^b	50-1,200 ^{b,c}	Extensive, rice fieldsd	
BANGLADESH	28,000 ^e	n.a.	30-50 ^e	Extensive, rice fields ^e	
INDONESIA	193,700 ^f	1,000,000g	100-300 ^c	Extensive, polyculture ^{b,c}	
THAILAND	36,400 ^h	100,000 ^h	100-300 ^c	Extensive, polyculture ^{b,c}	
PHILIPPINES	176,000 ⁱ	400,000 ⁱ	100-300 ^{b,c}	Extensive, polyculture ^{b,c}	
MALAYSIA	675 ^j	50,000j	1,000 ^j	Semi-intensivej	
TAIWAN	3,200 ^b	3,200 ^k	15,000 ^b	Intensive ^b	
CHINA	IA 8,200 ^k n		90k	Extensive ¹	
LATIN AMERICA					
ECUADOR	60,000 ^m	70,000 ^{m,n}	240-1,200 ⁰	Semi-intensive ⁰	
PANAMA	2,500P	6,000p	300-2,000P	Semi-intensive ^C	
PERU	3,200 ^p	6,000P	500P	Semi-intensive ^p	
BRAZIL	3,000A	8,100 ^k	n.a.	Extensive ^r	

Table 1						
Tropical Shrimp Mariculture:	Regional and National Comparisons					

SOURCES:

- a National Marine Fisheries Service (1985a)
- b Shang (n.d.)
- c Pedini (1981)
- d Kurian and Sebastian (1982)
- e Kibria (1985)
- f Directorate General of Fisheries (1985)
- g Ling (1973)
- h American Embassy, Bangkok (1986)
- ⁱ Peterson and Schmittou (1985)
- j American Embassy, Kuala Lumpur (1986)
- k National Marine Fisheries Service (1984)
- 1 UNDP (1979)
- m McPadden (1984)
- n Parodi (1985)
- ^o Mock (1983)
- p Weidner (1985b)
- q National Marine Fisheries Service (1985b)
- r Scott (1985)

Table 2
Shrimp Farming in the Caribbean and Latin America [*]
(metric tons)

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COUNTRY	1982	1990	
 Ecuador	21 500	40.000	
Panama	2,500	4 500	
Brazil	400	4,000	
Peru	600	3.500	
Honduras	250	2,500	
Mexico		2,000	
Colombia		2,000	
Venezuela		1,500	
Belize		1,500	
Bahamas		1.300	
Guatemala	100	1,000	
Martinique	150	750	
Others	25	5,250	
 TOTALS	25,325	69,800	

* Includes fresh water shrimp.

Source: Chamberlain (1985a).

REGION/COUNTRY	1986a			2000		
	Hectares (ha)	kg/ha/yr	Harvest (m.t.)	Hectares (ha)	kg/ha/yr	Harvest (m.t.)
ASIA						
INDIA	30,000	150	4,500	73,000b	750b	54,750
BANGLADESH	28,000	50	1,400	40,000	350	14,000
INDONESIA	193,700	200	38,740	250,000	500	125,000
THAILAND	36,400	200	7,280	70,000	500	35,000
PHILIPPINES	176,000	200	35,200	200,000	500	100,000
MALAYSIA	675	1,000	6,750	5,000	500	25,000
TAIWAN	3,200	15,000	48,000	3,200	15,000	48,000
CHINA	8,200	90	738	?	?	?
Sub-Totals	<u>476,175</u>		<u>142,608</u>	<u>641,200</u>		401.750
LATIN AMERICA						
ECUADOR	60,000	800	48,000	70,000	1,000	70,000
PANAMA	2,500	1,500	3,750	5,000	1,500	7,500
PERU	3,200	500	1,600	5,000	800	4,000
BRAZIL	3,000	500	1,500	15,000	800	12,000
Sub-Totals	<u>68,700</u>		<u>54,850</u>	<u>95,000</u>		<u>93,500</u>
<u>TOTALS</u>	<u>544,875</u>		<u>197,458</u>	736,200		<u>495,250</u>

 Table 3

 Tropical Shrimp Mariculture: Projected Development to Year 2000

NOTES:

a Estimates for year 1986 based on data in Table 1, as modified by personal experience and judgement.

b Estimates for Indian production in year 2000 based on data in Table 2. Estimates for all other countries at year 2000 based on educated guesswork.

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