

The Shrimp Aquaculture Sector in Thailand: A Review of Economic, Environmental and Trade Issues.

Direk Patmasiriwat, Onno Kuik and Sunil Pednekar.

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Direk Patmasiriwat is former Senior Research Specialist at the Thailand Development Research Institute (TDRI), Bangkok. Onno Kuik is Senior Economist at the Institute of Environmental Studies (IVM), Amsterdam. Sunil Pednekar, former Senior Researcher at the TDRI, is currently a Ph.D. candidate in Geography at the University of Sydney. They may be contacted at:

TDRI
565 Ramkhamhaeng 39
(Thepleela 1)
Ramkhamhaeng Road
Wangthonglang Bangkok district
Bangkok 10310
THAILAND

Tel: 662 718 5460
Fax: 662 718 5461

IVM
Vrije Universiteit
de Boelelaan 1115
1081 HV Amsterdam
the NETHERLANDS

Tel 31 20 444 9555
Fax: 31 20 444 9553
email: onno.kuik@ivm.vu.nl

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Environmental Economics Programme
IIED, 3 Endsleigh Street
London WC1H 0DD, UK
Tel +44 (0)171 388 2117; Fax +44 (0)171 388 2826
e-mail: Jacqueline.Saunders@iied.org

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IVM, Vrije Universiteit
De Boelelaan 1115
1081 HV Amsterdam
The Netherlands
Tel: +31 20 444 9555; Fax: +31 20 444 9553
e-mail: secr@ivm.vu.nl

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Abstract

Shrimp farming in Thailand has become a multi-billion dollar industry and a major export earner. Thailand is now the world's leading exporter and the largest producer of Black Tiger prawns, and supplies 20 percent of the world trade in shrimp and prawn. While the rapid growth of shrimp farming in Thailand has led to an economic boom, especially in the coastal provinces of the Eastern and Southern regions, there is doubt about the success of the industry long-term. Shrimp farming can be characterised as a boom-and-bust industry, where the money earned in the booms have not necessarily 'trickled down' to traditional coastal communities. Intensive shrimp farming causes negative environmental and socio-economic impacts: marine shrimp farming has encroached upon about 17 percent of Thailand's mangrove forest area and environmental pollutants such as nitrogen, phosphorus, suspended solids, chemical and drugs, and antibiotic substances, not only pollute off-site environments, but they also cause on-site pollution, threatening the long-term sustainability of the sector. The Thai shrimp industry also faces threats from Northern consumers concerned for their health and the environment. If the shrimp industry cannot respond to these all the challenges in an effective manner, its future prospects may be bleak. On the other hand, if the industry can make the transition to more sustainable production, its comparative advantage in the international market could even be enhanced vis-à-vis less sustainable competitors.

This paper is an output from the project "Environmentally Sensitive Sectors: Shrimp Farming in Thailand" of the CREED program. The main objective of the project is to study the responses of a resource intensive sector in a developing country which is sensitive to domestic and international environmental pressures. This paper presents a review of the literature of economic, environmental and trade issues of the shrimp farming sector in Thailand

Resumen

El cultivo de langostinos se ha convertido en una industria de miles de millones de dólares en Tailandia y una línea importante de exportación. Tailandia es en la actualidad el principal productor de langostinos negros gigantes y contribuye en un 20 por ciento del comercio mundial de langostinos y camarones. El crecimiento rápido de esta industria ha producido un auge económico en las provincias costeras del este y del sur. Sin embargo, a pesar del éxito actual, hay dudas acerca del futuro a largo plazo de esta industria. La industria de langostinos se ha caracterizado por fuertes altibajos en donde la riqueza de las épocas de auge no se ha filtrado a las comunidades costeras. Además, el cultivo intensivo de langostinos ha producido impactos negativos en los planos socio-económicos y ambientales. El cultivo marino de langostinos ha invadido alrededor del 17 por ciento del área de bosques de manglares en Tailandia. Contaminantes ambientales como el nitrógeno, el fósforo, los sólidos en suspensión, químicos, drogas y sustancias antibióticas no sólo contaminan ambientes distantes sino que causan contaminación local, la cual amenaza la sustentabilidad a largo plazo del sector. La industria tailandesa de langostinos también se ve afectada por los consumidores del Norte, quienes se preocupan por su salud y por el medio ambiente. Si la industria de langostinos no responde debidamente a todos estos retos, su perspectiva futura puede debilitarse. Por otra parte, si la industria logra pasar a una producción más sustentable, su ventaja comparativa en el mercado internacional puede aumentar frente a una competencia menos sustentable.

Este artículo hace parte del proyecto "Sectores ambientales claves: cultivo de langostinos en Tailandia" del programa CREED. El objetivo principal del proyecto es estudiar las respuestas de un sector intensivo de recursos en un país en vías de desarrollo que puede responder a presiones ambientales nacionales e internacionales. Este artículo presenta una revisión de la literatura económica, ambiental y comercial referente al cultivo de langostinos en Tailandia.

Abrégé

En Thaïlande, l'astaciculture (élevage de la crevette) est un secteur qui vaut désormais des milliards de dollars et est devenu une source majeure de recettes à l'exportation. Maintenant premier exportateur et plus grand producteur mondial de crevettes de la catégorie « Black Tiger », ce pays alimente à hauteur de 20 % le commerce mondial des crevettes et gambas. La rapide croissance de cette activité a engendré un boum économique dans les provinces côtières des régions est et sud de la Thaïlande. Pourtant, malgré la réussite actuelle de ce secteur, on s'interroge sur son avenir à long terme. L'astaciculture se caractérise par une alternance de croissance et d'effondrement et la diffusion des rentrées des périodes de boum n'a pas nécessairement atteint les communautés traditionnelles du littoral. Qui plus est, la pratique intensive de cet élevage a des effets écologiques et socio-économiques délétères. L'astaciculture en milieu marin s'est emparé d'approximativement 17

Des polluants nocifs pour l'environnement, tels que l'azote, le phosphore, les substances en suspension (solides, produits chimiques et médicaments) ainsi que les antibiotiques, ne se contentent pas de s'attaquer aux milieux environnant les sites de production, mais sont aussi la cause d'une pollution des sites eux-mêmes, ce qui menace la durabilité du secteur à long terme. L'astaciculture thaïlandaise est aussi en butte aux menaces des consommateurs du nord, inquiets pour leur santé et pour l'environnement. Si elle ne parvient pas à réagir efficacement à tous ces défis, ses perspectives d'avenir risquent fort de d'être sombres. Alternativement, si elle peut faire la transition vers un mode de production plus durable, elle pourrait même jouir, vis-à-vis de concurrents aux productions moins durables, d'un avantage comparatif accru sur le marché international.

Secteurs écologiquement sensibles: l'élevage de la crevette en Thaïlande ce dernier faisant partie du programme CREED. Ce projet vise principalement à étudier les réactions de secteurs qui font un usage intensif des ressources d'un pays en développement, lui-même sensible aux pressions écologistes domestiques et internationales. Le texte passe en revue la documentation consacrée aux problèmes économiques, écologiques et commerciaux de l'astaciculture thaïlandaise.

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Introduction

The world marine shrimp¹ aquaculture industry has experienced rapid changes over the past few decades. While the world production of captured shrimp has been fairly stable in recent years, that of cultured shrimp has expanded rapidly, from about 200,000 tonnes in 1980 to around 758,000 tonnes in 1995, and now accounts for nearly 30 percent of the global supply of marine shrimp (ASCC, 1995; Briggs, 1994).

The rapid expansion of shrimp farming has been facilitated by new technologies such as hatchery-production of shrimp fry and formulated feed. This has had significant impacts on the economic, socio-economic and natural environments. Economically, the expansion has encouraged a number of associated businesses such as feed and chemical manufacturing, hatchery, cold-storage, food processing, export industry networks, and contract farming involving large private enterprises in association with a large number of small-scale shrimp farmers. While these businesses have generated employment both in coastal areas and in industrial and commercial centres, conversion of rice fields, salt farms, orchards, coconut plantations and other coastal land uses to shrimp farms has had detrimental socio-economic impacts on coastal rural populations in many developing countries. Similarly, the rapidly growing shrimp farming industry has had adverse environmental impacts; including destruction of mangrove forests and other coastal wetlands, pollution of coastal waters and land from farm effluent discharge and sediment disposal, saltwater intrusion, land subsidence, land dereliction from abandoned farms, increased incidence of algae bloom in coastal waters, and possible changes in species composition in adjacent wetlands (Briggs, 1994; Dierberg and Woraphan, 1996). In addition to the off-site ecological impacts, large scale and intensive shrimp farming sets into motion a number of environmental feedback effects (for example through water exchange), which threaten the long-term sustainability of the industry itself (Macintosh and Phillips, 1992).

In Thailand, shrimp farming has become a multi-billion dollar industry and is now a major export earner. In 1996, export of farmed shrimp earned Thailand US\$ 2.5 billion², representing about 56 percent of the country's total fishery exports, or 3.5 percent of its total exports of goods and services. Thailand is the world's leading exporter and the largest producer of Black (or Giant) Tiger prawns (*Penaeus monodon*), supplying 20 percent of the world trade in shrimp and prawn.

¹ According to FAO terminology, "prawns" refer to freshwater species, while "shrimp" refer to their marine and brackishwater relatives. In common language large shrimp are often called "prawns" and small shrimp "shrimp", irrespective of the salt content of their habitat (Fast 1992:6). This paper deals with marine shrimp, though the most important species, *Penaeus monodon*, is, because of its size, called the Black Tiger Prawn.

² At an exchange rate of 1US\$ = 25 baht, approximately.

The devaluation of the Thai baht following its floating in July 1997, has raised the stakes in shrimp farming even further. Preliminary figures for 1997 indicate a 21 percent increase in export value (in baht terms), despite an eight percent decline in the volume of export (Table 1). Shrimp aquaculture activities have increased as a result. Shrimp farmers, constrained by a scarcity of suitable sites and threats of pollution and diseases in coastal areas, are moving further inland. They employ innovative techniques such as trucking in seawater or brine to farms located on fertile agricultural land (The Nation, 1998; Bangkok Post, 1998), with potentially serious environmental implications.

However, the Thai shrimp industry is beginning to face a number of obstacles on the world market. These are partly commercial, but increasingly the sensitivity of Thai shrimp exports to health and environmental concerns in wealthy consumer countries is having an impact on the production. In Germany, for example, the environmental NGO, Greenpeace, has requested consumers to reject shrimp products from Asia and Latin America on the grounds that shrimp farming is the major cause of mangrove forest destruction and water pollution, and that shrimp farming results in undesirable social changes in coastal communities. Similarly, in 1996, the US temporarily imposed an import ban of Thai shrimp because of the lack of effective protection of sea turtles during shrimp capture.³ Indeed, the recent proposal to ban inland shrimp farming seems to be prompted, at least partly, by the fear of possible criticism by environmental groups and its impact on shrimp exports. As environmental awareness increases among Northern consumers, the environmental conditions of production may become an important element in the sustainability of Thai shrimp exports.

The objectives of this paper are twofold. The first is to review developments in the shrimp aquaculture sector in Thailand with an emphasis on economic and environmental factors. Recently there have been a number of reviews of the Thai shrimp sector, but most have focused either on environmental aspects (eg, Briggs, 1994; Briggs and Funge-Smith, 1994; Dierberg and Woraphan, 1996; Macintosh and Phillips, 1992; Phillips et al., 1993) or broadly on macroeconomic aspects. An example of an integrated study is Dewalt et al. (1996) who assess shrimp development in the Gulf of Fonseca, Honduras, from an integrated social, economic and environmental perspective. Dewalt et al. analyse the development of shrimp farming in the Gulf as a state-assisted transformation of the former common property regime of the Gulf's natural resources towards a private property regime in favour of commercial shrimp farming corporations. The private property regime currently operating in the Gulf on the one hand creates (uncompensated) externalities towards other uses, such as fishing, hunting, collecting shellfish, gathering wood etc, and on the other hand destroys its own resource base, thereby jeopardising the long-term, sustainable economic development of the region (Dewalt et al., 1996).

³ It should be noted that although 80 percent of Thai shrimp production comes from farm culture, the fact that many farms are not registered makes it difficult to label the shrimp on the basis of origin. The US ban, which came into effect in May 1996, was lifted in the autumn of the same year. The process of shrimp farm registration, started in 1991, has not yielded satisfactory results so far.

The second objective of the paper is to review responses to environmental problems by the shrimp-farming industry, the Thai government and the international trading community, respectively. Specifically, it draws attention to the possible implications of the apparent emergence of “green consumerism” in the major export markets for Thai shrimp.

The structure of the paper is as follows. The first section presents an overview of the Thai shrimp industry in terms of its historical development and its present structure. This is followed by an analysis of farm-level economics of shrimp farming. Next, the main environmental impacts of shrimp farming are identified. These include mangrove destruction and on- and off-site pollution of land and water. Section 5 discusses the shrimp diseases often associated with intensive farming and water pollution. Section 6 reviews environmental policies of the Thai government. International trade issues and its potential impacts on Thai shrimp farming are discussed in Section 7, with Section 8 concluding.

Shrimp Farming In Thailand

Historical Background

Marine shrimp farming has been operating in the Inner Gulf of Thailand for over 60 years⁴ (Banchong, 1970; Siri, 1996; Sutonya, 1995). Early practices were simple and involved trapping shrimp larvae and adults in tidally flooded low-lying coastal areas (Dierberg and Woraphan, 1996). The species reared included banana shrimp (*Penaeus merguensis*), school shrimp (*Metapenaeus ensis*) and a small volume of black tiger prawn (*P. monodon*) (Sutonya, 1995).

A depression in salt prices in 1947 encouraged salt farmers in the Inner Gulf of Thailand to convert their lands to shrimp farms (Banchong, 1970; Supee, 1991). These “first actively-managed” extensive farms occurred along the upper coasts of the Inner Gulf of Thailand, immediately south of Bangkok (Dierberg and Woraphan, 1996). Like earlier traditional practices, these extensive farms relied on the juvenile shrimp and nutrients in sea water which was trapped during high tide into an 8-16 ha enclosure with high dikes and a sluice gate; they differed however, in that the farmers allowed daily tidal water exchange of 5 to 10 percent (*ibid.*). In both systems, no additional feed was provided beyond the naturally occurring sea organisms. Most of the incoming shrimp seed were white or banana shrimp (*Penaeus merguensis*). The first crop was usually harvested between November and February, the time of the weaker, north-east monsoon when high salinity yielded higher outputs. The second crop occurred during the rainy season (south-west monsoon), but the output tended to be low due to a drop in salinity levels (Panu and Siri, 1995).

Early statistics recorded by the Department of Fisheries (DoF) in 1971 indicate that there were 1,137 shrimp farming households occupying a total farm area of 8,712 ha or 54,447 rai⁵ (TDRI, 1986). A survey conducted in 1969 (Banchong, 1970) showed that 98 percent of the farms were located in estuaries of the Inner Gulf of Thailand, in the provinces of Samut Prakarn, Samut Sakhon and Samut Songkhram, and the rest scattered along the coasts of Chanthaburi, Nakhon Si Thammarat and Rayong; interest in shrimp farming was also developing in Southern provinces such as Surat Thani and Songkhla (see Figure 1). Most farmers adopted an extensive polyculture method (less than 10 shrimp/m²) using finfish as feed. During the 1970s the area of brackish waterponds steadily increased.

⁴ See Figure 1 for a map of Thailand's coastal provinces and its major shrimp farming areas.

⁵ 6.25 rai = 1 ha, or 1 rai = 0.16 ha.

map

By the late 1970s, the introduction of hatchery technology (see below) enabled farmers to adopt semi-intensive production methods in which hatchery-reared seed supplemented wild fry. This semi-intensive farming, common by the early 1980s, was characterised by smaller ponds (3-5 ha), higher stocking densities (5-10 animals/m²), a supplementary diet in the form of dry and/or wet feed, increased daily water exchange (up to 40%) using inexpensive “push pumps”, and two to three times higher yields (Dierberg and Woraphan, 1996).

In 1967, the DoF started to promote freshwater prawns (*Macrobrachium* spp., but particularly *M. rosenbergii*), following the successful rearing of *M. rosenbergii* post-larvae for stocking ponds in 1966 at the Songkhla and Bangkok fisheries station (Somsak et al., 1980). By the 1970s, there were two government-run freshwater prawn hatcheries in Songkhla and Chachoengsao to produce and distribute post-larvae to prawn farmers and stock in the brackish water part of the Songkhla lake (ibid.). Several commercial hatcheries and a number of small-scale backyard hatcheries also developed during this period, with the total annual output exceeding 32 million post-larvae during the late 1970s (ibid.).

When the supply from the freshwater prawn industry exceeded demand, pushing down the market price, the Thai government changed its policy by supporting the conversion of freshwater *Macrobrachium* hatcheries to brackish water penaeid hatcheries.⁶ These hatcheries concentrated on producing *P. monodon* due to its large size and rapid growth rate (Briggs, 1994), and a growing demand for the species in overseas markets, especially Japan. Although Thailand had succeeded in producing *P. monodon* larvae as early as 1974, large scale production did not take place immediately, as both local and overseas markets for the species were not developed. As a result, both prices and profit margins were low (Hassanai, 1990).

In the early 1980s, Taiwan became the first country in Asia to transform traditional extensive shrimp cultivation into intensive farming of the *P. monodon*. High stocking densities, artificial feeding, chemical treatment of water and the use of antibiotics, dramatically increased production. Initially, Taiwan subsidised exports to maintain low prices until the Japanese market developed for black tiger shrimp (Hassanai, 1990). Other countries in South East Asia followed the Taiwanese example and established intensive shrimp aquaculture. In Thailand in 1987, production increased 32 percent over the previous year despite a slight decrease in area, and in the following years, both area and production increased rapidly (Table 1).

It is important to note that in many countries, these developments were supported by international financial organisations such as the World Bank and the Asian Development Bank. While the initial focus of their support was to “meet the income and nutrition needs of impoverished rural areas”, this changed when the export potential of shrimp aquaculture became apparent (Gronski and Heffernan, 1996). In Thailand, for example, the Asian Development Bank approved a US\$ 11.1 million loan in 1986 for a brackish water shrimp culture development project (Goss et al. forthcoming). These institutions, together with the national bank, ‘acted as catalysts for private sector investment’ providing core funds for feasibility studies and the required infrastructure (ibid.). The technical knowledge of intensive

⁶ This conversion was possible because *Macrobrachium* post-larvae require low-salinity brackishwater, and therefore most hatcheries, barring some small-scale, backyard operations, were located near the coast (see Somsak et al., 1980). Furthermore, Hassanai (1990) points out that the simple, flexible design of backyard hatcheries made it easy to switch to *P. monodon*.

farming of *P. monodon* was initially supplied by technicians from Taiwan, the then leading exporter of farmed shrimp (Briggs, 1994).

Table 1. Number of Shrimp Farms, Culture Area, Production and Value, 1972-97
(Area: ha; Quantity: tonnes; Value: million baht)

Year	No. of Farms	Area (ha)	Production		Exports	
			Quantity	Value	Quantity	Value
1972	1,154	9,056.32	991.00	20.50	N/A	N/A
1973	1,462	11,468.48	1,635.00	35.30	N/A	N/A
1974	1,518	12,092.16	1,775.00	43.20	N/A	N/A
1975	1,568	12,867.52	2,538.29	81.80	N/A	N/A
1976	1,544	12,296.00	2,533.33	79.45	N/A	N/A
1977	1,437	12,410.72	1,589.54	56.09	15,615.95	1,280.63
1978	3,045	24,168.80	6,394.83	349.16	17,515.78	1,653.00
1979	3,378	24,675.52	7,064.07	460.59	21,481.34	2,601.01
1980	3,572	26,036.32	8,063.05	458.91	20,377.42	2,170.02
1981	3,657	27,459.04	10,727.87	657.26	21,510.57	2,368.74
1982	3,943	30,792.48	10,090.77	765.68	27,620.58	3,178.24
1983	4,327	35,537.12	11,549.85	950.37	25,675.38	3,612.51
1984	4,519	36,791.84	13,006.75	1,024.01	37,294.19	4,267.35
1985	4,939	40,768.80	15,840.56	1,348.42	42,196.72	4,999.90
1986	5,534	45,367.68	17,885.83	1,737.58	49,921.27	6,222.09
1987	5,899	44,769.92	23,566.47	3,449.32	60,216.25	8,321.46
1988	10,246	54,778.24	55,632.84	7,900.55	76,147.72	12,733.62
1989	12,545	71,165.60	93,494.50	11,072.19	94,277.55	18,545.48
1990	15,072	64,605.92	118,227.05	14,365.36	116,913.85	25,789.70
1991	18,998	75,332.16	162,069.69	19,834.11	160,214.87	33,811.87
1992	19,403	72,796.00	184,884.32	25,500.14	182,646.51	40,149.38
1993	20,027	71,886.72	225,514.30	32,425.34	195,402.06	48,136.12
1994	22,198	73,246.88	263,445.96	39,845.25	241,052.64	63,241.53
1995	26,145	74,941.76	259,540.54	39,544.65	237,479.04	67,439.57
1996	N/A	N/A	259,541.00	N/A	231,268.66	62,827.52
1997 ¹	N/A	N/A	258,000.00	N/A	212,867.71	75,958.59

Note: Figures for 1997 are preliminary.

Sources: DoF (1997), Customs Department and Department of Business Economics

From about 1986, Thailand began producing Black Tiger prawn along the northern edge of the Gulf of Thailand (from Samut Songkhram to Chonburi). Following a production crash in the Taiwanese shrimp industry during 1987-90 and the consequent rise in world shrimp prices, Thailand's cultured shrimp production increased rapidly, motivated by high profit margins. Despite the high initial investment costs, farmers could earn revenue from the first harvest within four months, and two to three crops could be obtained in one year.

In many places, intensive shrimp farming has been characterised by a boom-and-bust cycle of rapid expansion followed by a crash (Csavas, 1992; Goss et al., forthcoming). As in Taiwan and elsewhere (Csavas, 1992), this cycle also occurred in Thailand, when the Inner Gulf region, particularly the provinces of Samut Prakarn and Samut Songkhram, suffered a catastrophic production crash in 1990, just a few years after intensive shrimp farming began in these provinces. The disease outbreaks which destroyed the crop were attributed to the stress created by the poor water quality in the Inner Gulf of Thailand (see, for example, Briggs and Funge-Smith, 1994). Apart from farm self-pollution, the Gulf also receives urban, industrial and agricultural waste water carried by some of Thailand's major river systems, including the Chao Phraya (on which Bangkok is situated) and the Mae Klong (which carries wastewater from sugar factories in western Thailand). Poor mixing of water in the Inner Gulf due to its characteristic topography exacerbated the problem. The 1990 production crash forced about 90 percent of shrimp farmers in this region out of business and left some 45,000 ha of farms abandoned - an area that once supported productive rice fields and mangrove forests (Briggs, 1994).

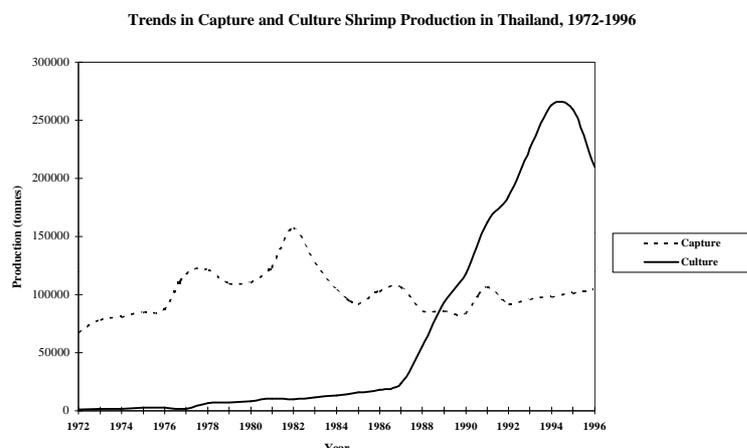
However, unlike the Taiwanese shrimp industry which was concentrated in one area with little room for further expansion, the Thai shrimp industry, was able to migrate and expand from the northern (Inner) Gulf region toward the East (Chanthaburi and Trad) and South (Prachuab Khiri Khan, Surat Thani, Nakhon Si Thammarat) and then across to the Andaman Coast (Krabi, Phang-nga and Satun) (See Figure 1). This migration, together with steady improvements in farming methods, seed supply and technology, and support from the government in various forms, enabled Thailand to increase production continually despite localised production crashes.

The production crash in the Inner Gulf was thus followed by a boom in shrimp farming in the more favourable conditions of the Eastern and Southern provinces. According to Briggs (1994), these conditions included a location away from industrial and urban pollution, healthier sea water quality, and opportunities to abstract water directly from the sea rather than via common canals.

Figure 2 shows the trend in the volumes of captured and cultured shrimp production in Thailand between 1972 and 1996. It can be seen that from 1983 captured shrimp production declined, probably following the declaration of the exclusive economic zones (EEZs) by Thailand's neighbours, which resulted in the reduction of the fishing grounds for Thai fishing fleets (Sutonya, 1995). On the other hand, cultured production increased rapidly at the end of the 1980s, and has, since 1990, exceeded captured shrimp production. The rise at the end of the 1980s can be attributed to the Taiwanese crash, the subsequent increase in world market prices, the widespread use of the Taiwanese intensive farming technology, and the accompanying expansion of shrimp farming along the eastern, southern and Andaman coasts. Note that while the production crashes during the late 1980s along the Northern Gulf region are not apparent in the curve due to the simultaneous expansion to the East and South, the

widespread production crashes following disease outbreaks in 1996 are clearly shown by a sharp decline.

Figure 2. Trends in capture and culture shrimp production in Thailand: 1972-1996



Source: Department of Fisheries

Structure and geographical distribution of the shrimp farming industry

As at 1995, there were about 26,000 shrimp farms in Thailand (DoF, 1997). Most of these are located within a 3-5 km belt along the country's 2,600-km coastline in the Central, Eastern and Southern provinces. About 80 percent of the farms can be classified as small, with a farm area no larger than 1.6 ha (Siri, 1996). About 77 percent of the farms are intensive, although by area they represented only 51 percent of the total area under shrimp production in 1993 (Table 2). Of the total cultured shrimp production of 263,446 tonnes in 1994, *P. monodon* accounted for 98 percent. About 85 percent of the production is exported, the rest is consumed domestically.

Table 2. Types of Shrimp Farms in Thailand, 1993

Type	Number of Farms	Area (ha)	Production (tonnes)
Extensive	3,031	24,410	5,250
Semi-intensive	1,522	10,908	3,750
Intensive	15,474	36,569	216,514
Total	20,027	71,887	225,789

Source: Department of Fisheries

Associated Industries

The rapid growth of shrimp farming in Thailand has led to an economic boom in the coastal provinces of the Eastern and Southern regions and has stimulated industries and businesses associated with its production. These include: capture and supply of wild broodstock by fishermen; hatchery production of shrimp seed and supply; manufacture and sale of shrimp farming equipment (eg, paddle-wheels); live and pelleted feed processing; cold storage plants; and shrimp processing and export.

While at the farm level the Thai shrimp sector is characterised by a high proportion of small businesses, the more capital- and technology-intensive associated industries, particularly pelleted feed manufacturing, shrimp processing and export, are dominated by a small number of large ones. As Csavas points out:

“[I]n shrimp culture development there are basically two avenues: one for vertically integrated large corporations (which may or may not include horizontally integrated contract farmers) and another for medium scale or small producers who must either join a contract farming system or participate in an integrated network of specialised suppliers, contractors and brokers in order to successfully compete in an increasingly tight market. (Csavas, 1992:15)

In Thailand, both avenues have been developed. However, linkages exist between the two. The large corporations are linked with farmers either directly through their own networks of suppliers and buying agents (Goss et al., forthcoming) or indirectly through middlemen, by supplying feed and seed, as well as technical know-how and services such as chemical and microbiological analyses of shrimp and water samples, disease and water quality diagnosis, and sometimes by arranging contractual production schemes.

The largest of the corporations is the CP Group, a Thai-based conglomerate that is now the world's largest shrimp exporter with operations in Vietnam, China, India, Cambodia and Bangladesh.⁷ The CP Group is also the largest supplier of pelleted feed in Thailand, and controls 60-70 percent of the market, followed by a dozen others who share about 1-4 percent (ASCC, 1995; Goss et al., forthcoming). The CP Group entered the shrimp business in Thailand in the mid- to late-1980s, and has operations ranging from feedmills, shrimp processing plants, laboratory testing and diagnostic services for shrimp farmers, as well as hatcheries and demonstration farms. Its 14 extension centres are well-equipped with laboratories (including some mobile units) and the services of experienced biologists. The centres provide free water quality testing or disease diagnosis and advice, and hold seminars and free training. The CP Group has also planned research to develop a domestic shrimp species using genetic engineering (Goss et al., forthcoming; Boonserm Witthayapanyakul, pers. comm. March 1996).

There are about 70 shrimp processing plants and cold-storage facilities, with a combined total annual processing capacity of 40,000 tonnes of frozen black tiger shrimp. The hatchery

⁷ Another large-scale operation based on contract farming, and run by Aquastar, a former subsidiary of British Petroleum, a UK-based transnational corporation, went out of business recently (see, e.g., Goss *et al.*, forthcoming).

operations are comparatively well distributed among small and large operators, with 30 large hatcheries; and at least 1,000 backyard hatcheries and nurseries. Most of the latter are unregistered, and are often the source of diseased, unhealthy seed. Although it is possible to breed shrimp in laboratories by inducing maturation in non-gravid females from wild stocks or culture ponds (Piamsak et al., 1994), the hatcheries generally depend on wild broodstock, preferably caught in off-shore ocean areas (Boonyarath et al., 1993; Piamsak et al., 1994). Gravid female shrimp caught in off-shore waters are usually better quality than wild near-shore or estuarine or pond-reared broodstock, and yield large quantities of high quality eggs and nauplii. Best quality *P. monodon* broodstock are gravid females at maturation stage IV, weighing over 200g (Boonyarath et al., 1993). They fetch a very high price, but are in limited supply and pose logistical and economic constraints on culture production (ibid.). In early 1996, the average price for a gravid female shrimp was around 2,800 baht/animal, many times the market price for a regular shrimp (Boonserm Witthayapanyakul, pers. comm. March 1996).

The Farm-level Economics of Shrimp Farming

The production process

The predominant system of management in Thailand is intensive culturing. This may be divided into four stages: pond preparation, stocking, culturing and harvesting. Pond preparation for the next production cycle normally begins immediately after the harvest and can take up to one month. After harvesting, the farmer drains the pond and removes the wet mud by tractor or backhoe. Smaller farms who cannot afford to pay for a tractor simply scour the pond bottom using strong water jets. While the pond is drying, the farmer spends time on dike and drainage repairs. Acid sulphate soils, such as those on previous mangrove areas, turn acidic upon exposure to air, so farmers commonly apply lime to reduce acidity. Lime is also commonly used to sterilise pond sediments between crops (Phillips et al., 1993). A farm survey by NACA (1996) revealed that 90 percent of Thai shrimp farmers spray lime. A number of chemicals and substances such as tea seed cakes are used to reduce pests. Sea water is pumped into the pond after it has dried out, and the farmer waits for the plankton to multiply until they reach a sufficiently high concentration. Phytoplankton are necessary for shrimp in the early growth period (Hassanai, 1990), as are zooplankton and other benthic organisms predated upon by shrimp (Chen and Chen, 1992). Water depth is usually 1.2 to 1.5m initially, and in the later stages of production raised to 1.8m.

At the second stage, the farmer stocks shrimp postlarvae; for *P. monodon*, a stocking rate of 69 animals/m² is usually adopted, although densities as high as 100 animals/m² are not uncommon. The stocking rate is a key variable in the economic and environmental management of the farm. As will be explained below, high stocking rates increase short-term profitability, but also negatively affect water quality and the occurrence of disease (Briggs and Funge-Smith, 1994).

The third stage, culturing, involves water management, feeding, aeration, and disease management. Water exchange is carried out to control water quality and to maintain the concentration of plankton at appropriate levels. High water exchanges of up to six times during the final month before harvesting have been reported (NACA, 1996). However, a number of farmers have been adopting low (2.6 times per crop on average) to zero water exchange (Funge-Smith and Aeron-Thomas, 1995), mainly for fear of disease carriers and pollution entering through seawater.

About 79 percent of the intensive shrimp farms in Thailand use manufactured shrimp feed, while others may use fresh fishery products. Together with stocking densities, the feed conversion ratio (FCR) is a key variable in economic and environmental management. The FCR is defined as the ratio of the dry weight of the feed administered and the wet weight of biomass increase. The commonly achieved FCR is about 1.7, ie, 1.7 kg of feed produces 1 kg of shrimp biomass (ADB/NACA, 1995).

Aeration is necessary for intensive shrimp culturing to increase the level of oxygen in the water. When the aerators are properly placed, water currents can move the uneaten feed and faecal matter to the middle of the pond bottom, thus keeping the feeding area along the banks relatively clean. For a 1 ha shrimp farm, 7 aerators are common. These operate continually, except for an hour or two before and after feeding, to avoid dispersion of feed.

Disease management is a vital element of shrimp farming. Shrimp diseases can occur at any time from viruses and bacteria, and disease outbreaks may develop very quickly. For example, the yellow head virus (YHV), first reported in Thailand in 1990 in the Inner Gulf region, can cause a 100 percent mortality rate within 3-5 days of the first clinical symptoms, while the SEMBV (systemic ectodermal mesodermal baculovirus) can cause 10-70 percent mortality and up to 100 percent in 2-7 days (ASCC, 1995, Q4, no. 20, 1994). Experienced farmers immediately treat the pond with chemicals or antibiotics depending on the symptoms.

Penaeid shrimp themselves are carriers of a number of disease causing organisms. For example, *Vibrio* spp., the bacteria which have frequently caused severe production losses on shrimp farms, are typically part of the penaeid's normal microflora (Lightner et al., 1990). These organisms are, therefore, almost always present in pond waters, and can cause what are known as opportunistic infections when culture conditions favour their growth at the expense of their penaeid host (ibid.). A number of viruses may also infect shrimp at larval stage, but remain latent for large parts of the shrimp life cycle. Infections are frequently enhanced by stress induced from overcrowding, abnormal temperature, pollutants, and other factors (Stewart, 1993).

The fourth and final stage in the production process is harvesting, usually about 120-140 days after stocking. The usual method is to cover the pond gate with a net and to allow water to flow out of the pond. Some people develop their skill to become 'professional' harvesters in their communities, and their services are used when the supply of family labour is inadequate. The crop is usually sold at the farm right after harvesting (NACA, 1996).

Production economics

Location and size of the farm

Farm location is crucial to the success of shrimp farming. Traditionally, shrimp farms tended to be located in near-shore low-lying areas (eg, in mangroves) so that shrimp fry could be trapped with the incoming water during high tide without the need for a pump. However, there are disadvantages: it is more difficult to clear water out of the ponds in low lying coastal areas, and it is thus less likely that they are dried out properly before stocking. This makes farms more susceptible to diseases, as wet or semi-dried pond mud may harbour pathogens from the previous production cycle. On the other hand, locations far from the coastline and on high ground may facilitate pond drainage, reduce the chance of diseases and improve yields, but they require pumping which pushes up costs.

Most shrimp farmers believe that diseases may enter during water changes, and via disease carriers present in the intake water. This is certainly the case in areas where the density of farms is high and intensive culture is adopted. Here the amount of pollution discharged into canals and coastal waters as effluent is high, and so also is the risk of the pollution re-entering the ponds (“self-pollution”). Farmers try to minimise the disease and self-pollution risk by adopting a minimum or zero water exchange during the grow-out period. An estimated 82 percent shrimp farmers in Thailand practise water exchange of about 10 percent for no more than six times a month during the final month of culture (ADB/NACA, 1995, cited in NACA 1996:59), unlike the large daily exchanges common in extensive culture.

The acidity, organic content and structure of the soil are also important considerations for shrimp culture. Poor acid sulphate soils near the coast are not well suited for agriculture and therefore have a low opportunity cost. Acid soils, however, do require repeated lime treatments to maintain pond pH (Briggs and Funge-Smith, 1994). Ex-mangrove soils are usually acidic and have a high organic content, which may affect water quality and sediment oxygen demand. Ex-rice paddy soils also suffer from a high organic content and, in addition, may be polluted by pesticides (ibid.). Sandy soils suffer from high seepage rates (ibid.), and are, therefore, unsuitable.

The average size of a shrimp farm in Thailand is 3.6 ha (22.4 rai). The average size of an intensive shrimp farm is 2.4 ha (14.8 rai) and typically operate 2 to 4 ponds. Funge-Smith and Aeron-Thomas (1995), in their investigation of the economies of scale in shrimp farming, conclude that farm size significantly affects equipment costs and net revenue. The optimal farm would operate approximately 5 to 10 ponds. Net revenue increases up to a farm size of approximately 12 ha, and then drops at larger sizes (Funge-Smith and Aeron-Thomas, 1995).

Yield, prices and revenue

Typical yields are in the order of 5 to 9 tonnes per ha per crop, and two crops per year are common in Thailand. However, the variation in yields is extremely high. In a survey of 103 shrimp farms in the Southern provinces in 1994/95, Funge-Smith and Aeron-Thomas (1995) report a mean yield of 7050 kg per ha, with a standard deviation of 3850 kg. In a recent survey by TDRI among 348 farms in the Southern and Eastern provinces, a mean yield of 6731 kg with a standard deviation of no less than 5844 kg was reported (TDRI, in prep.).

The farm-gate price of shrimp depends primarily on their size. Large animals earn a much better price than small ones. Funge-Smith and Aeron-Thomas (1995) have calculated that if farmers grew larger shrimp, their total revenue would rise disproportionately to their operational costs. However, the fear of disease often impels farmers to harvest and sell the animals before they are fully grown. In the case of emergency harvesting due to a disease outbreak, prices are considerably depressed.

Mean total revenues of shrimp farms are in the order of US\$ 30,000 to US\$ 50,000 per ha per crop, with large variations among farms due to large variations in yields (Funge-Smith and Aeron-Thomas 1995; NACA 1996; TDRI, in prep.).

Fixed costs

Fixed costs include pond construction, investment costs for farm equipment (eg, aerators, water pumps, boats and pick-up trucks), and the opportunity cost of land. Farm equipment is usually the major fixed cost category, with pumps as the most expensive single item on the majority of farms (Funge-Smith and Aeron-Thomas, 1995). An assessment of the annual land costs is difficult because actual land transactions are rare. Different researchers have used different land costs as input, (from US\$ 300 to US\$ 2500 per ha per year). Funge-Smith and Aeron-Thomas (1995) estimate mean fixed costs at approximately US\$ 8000 per ha per crop.

Variable costs

The major items of variable costs include cost of feeds, seed (postlarvae), energy (electricity and gasoline), and chemicals and drugs. The major share of variable cost goes to feed (about 50%), followed by seed (postlarvae), and fuel. A typical farm has 1 to 2 family members to attend and feed the shrimps; at times when the demand for labour is high, hired labour is employed to perform certain tasks (eg., harvesting and pond cleaning). The variable costs are typically much higher than the fixed costs; Funge-Smith and Aeron-Thomas (1995) calculate mean variable costs at US\$ 30,000 per ha per crop.

Profits

Profits as percentages of total costs are estimated to be 17 percent (NACA, 1996) to 26 percent (Funge-Smith and Aeron-Thomas, 1995)⁸ which are relatively high. A study by Nattaya Srichantuk and Siri Tookvinas (1993) based on the survey data of 20 small-shrimp farmers in Chantaburi province confirms the relative profitability of shrimp farming. On average, Nattaya and Siri (ibid) found that a small farm earned a net income of US\$ 5300 per year (133,212 Baht), which was higher than rice farming in the same region. The NACA study (1996) also considered the calculated profit of 17 percent to be comparatively high.

In their study, Funge-Smith and Aeron-Thomas (1995) performed a sensitivity analysis on the impact of changes in revenue and cost items on farm profits. The item that most affected profitability was the shrimp price: a 10 percent change in shrimp price change affected profitability by 73 percent. Second and third were production weight (47%) and the feed price (26%).

⁸ Notice that the mean farm size in the Funge-Smith and Aeron-Thomas farm survey was 5 ha, againsts 1.4 ha in the NACA survey. The larger profit rate calculated by Funge-Smith and Aeron-Thomas is not inconsistent with the economy of scale hypothesis that was discussed earlier.

On this point it is also interesting to refer to a study by Primavera on the shrimp pond culture in the Philippines (Primavera, 1993). She compares three management systems for shrimp production: extensive, semi-intensive and intensive. The effect of price changes on the profitability of farms is much higher for intensive farms than for semi-intensive and extensive farms. With relatively high shrimp prices, the profitability of intensive farms is highest, but drops with shrimp price. Primavera (ibid) presents data on break-even prices for different management systems of Indonesian shrimp farms⁹. The break-even price for extensive and semi-intensive farms is US\$ 1.83 and US\$ 2.72, respectively. The break-even price for intensive farms is higher at US\$ 3.40 per kg, which suggests that the market risks of intensive farming are considerably higher.

Costs of pollution control

There are two types of pollution control costs: those within the pond environment (on-site pollution) and those from the pond to outer environment (off-site). Supee's study (1991) of the costs of pollution control for shrimp farming in Samut Sakhon Province, Inner Gulf of Thailand, classifies three types of shrimp farming: extensive, semi-intensive, and intensive and compares their costs and revenues. The extensive farming system does not incur any cleaning or treatment costs. The study identifies two types of cleaning costs incurred by semi-intensive and intensive farms - pond cleaning and wastewater treatment. Typically, cleaning involves water jets or tractors to move the dried mud to the edge of the pond. Wastewater treatment, in this study, refers to storing wastewater in the storage pond for the waste to settle before the water is discharged into a public waterway or the sea. The storage pond commands a large area -twice the size of a culturing pond or two-thirds the total area. Supee's findings include:

a) cost of pond cleaning

<u>farm size</u>	<u>baht/rai/crop</u>
1-50 rai	100.35 (25 US\$/ha/crop)
51-100 rai	179.84 (45 US\$/ha/crop)

b) cost of wastewater treatment

<u>farm size</u>	<u>baht/rai/crop</u>
1-50 rai	6,079 (1360 US\$/ha/crop)
51-100 rai	9,836 (2460 US\$/ha/crop)

The study does not provide information on how the samples were taken, nor does it report statistical cost estimation -only the representative statistics are reported.

⁹ The break-even price is the price at which the costs of production are just compensated by the revenues, leaving no profits

Evaluation

Farm surveys in Thailand have shown that shrimp farming is a profitable activity, at least in the short term. The cross-section surveys do not, however, provide information on the long-term success of individual farms, or, indeed, of the industry as a whole. In Section 2, it was noted that shrimp farming can be characterised as a boom-and-bust industry. For example, Central Thailand has 45,000 ha of derelict ponds abandoned after the production crash in 1989/90 (Briggs and Funge-Smith, 1994). This section has highlighted the commercial risks of shrimp farming, ie, the sensitivity of profits with regard to the market price of shrimps. In the next sections the environmental risks and sustainability of shrimp farming are discussed.

Environmental and Socio-economic Impacts of Shrimp Farming

There are many negative environmental and socio-economic impacts of shrimp farming in Thailand. In this paper we shall distinguish between land use changes (with particular emphasis on mangrove forests) and environmental pollution, and, with regard to the latter, between off-site and on-site pollution. Finally, we consider the negative socio-economic impacts on coastal communities created by commercial shrimp farming.

Land Use Change

The growth of shrimp farming in Thailand has demanded a large area of coastal land. During the period 1972-1995 the land area under shrimp cultivation increased from 9,000 ha to almost 75,000 ha (Table 1), at the expense of rice paddies, mangrove forests and other land uses.

Shrimp farming in Thailand is often blamed for the destruction of mangroves, since expansion in the former has coincided with the latter's decline. The term mangrove refers to salt-tolerant forest ecosystems or plant communities growing along sheltered tropical and subtropical coastlines (Hamilton and Snedaker, 1984; Hutchings and Saenger, 1987). Mangroves act as a buffer between land and sea, as a shelter belt for coastal land uses, nursery and sanctuary for non-aquatic as well as aquatic species, and as an economic resource for local coastal communities. Traditionally, the nursery function of mangroves has been exploited by extensive shrimp farmers locating their farms in or near mangrove areas which are a good source of wild shrimp fry.

In 1961 the area under mangrove forest in Thailand was estimated to be around 370,000 ha (2.3 million rai). By 1993, in a little more than three decades, it decreased by half, to 168,700 ha (1.05 million rai). Several factors contributed to the decrease, including urban and rural settlement expansion, port construction, salt farming, agricultural expansion and shrimp farming. In the absence of reliable data, estimates of the share of mangrove area lost to shrimp farms vary from 13 to 64 percent (eg, Briggs, 1994; Dierberg and Woraphan, 1996; Kanittha, 1994; Macintosh and Phillips, 1992; Ruangrai, 1994). Recently, however, a Joint Working Committee comprising the Department of Fisheries, Royal Forest Department, Land Development Department, and the National Research Council of Thailand - the four agencies concerned with coastal land use - has attempted to resolve the debate. Their new statistics, based on the comparison of remote sensing images (Landsat TM5, 1:50,000) and earlier land-use maps, indicate that about one-third (31%) of the reported mangrove forest loss is due to marine shrimp farming, or about 17 percent of the mangrove area in 1961 has been encroached by shrimp farms (Piamsak, 1996; Siri, 1996).

At present there is little knowledge on the biodiversity losses associated with the decline of mangrove forestry, although this is the subject of an on-going study by the Forestry Department of Kasetsart University, Bangkok (Sanit Aksornkoe, pers. comm.).

Environmental pollution

The main environmental impacts of shrimp farming are water and soil pollution. The main pollutants are nutrients (Nitrogen, Phosphorus), suspended solids, chemicals and drugs, and antibiotic substances. Water pollution can occur at the culturing stage, the harvesting stage, and the pond preparation stage (NACA, 1996).

Environmental impacts are at their lowest during the culturing stage. Although there may be some water exchange, pollutants from the discharged water are usually within the DoF's effluent standards, established under the Ministerial Announcement of 18 November 1991 of the Ministry of Agriculture and Co-operatives (Mac), which oversees the DoF (see Section 6 below). Under this Announcement, the BO (biochemical oxygen demand) levels of the effluent discharge from shrimp farms must be below 10 mg/l (NACA, 1996). NACA (ibid.) points out that it is during the harvesting stage, when effluent discharge contains waste and faecal matter accumulated at the pond bottom, that the BO levels are most likely to be higher than the DoF standards. However, given poor enforcement and lack of facilities, few polluters are ever penalised for violating the standards. The fact that it takes five days to estimate BO further discourages official action (NACA, 1996:150).

At the pond preparation stage, pond mud and sediments from the previous crop cycle are removed by scouring the pond bottom with water jets or with the use of a tractor. Most small farmers, lacking sufficient space to allocate for sediment disposal, deposit it in public canals or nearby areas. As the sludge may contain concentrated, sometimes even toxic levels of organic and inorganic matter and nutrients, this stage is possibly the most detrimental to the environment.

Among the off-site pollution externalities from shrimp farming are the impacts on marine water quality; on the production of near-shore fisheries; and on nearby rice paddies. For the latter, Briggs and Funge-Smith (1994) have reported that salinisation prevents rice farming in the vicinity of shrimp farms. In addition, once shrimp farms have collapsed in an area, conversion of land to other types of agriculture is difficult due to the salinisation of the soil. The impacts of shrimp farming on coastal fisheries is the subject of an on-going study at Bangkok's Chulalongkorn University, which focuses on a case study site in Surat Thani province. The research will attempt to quantify the reduction in near-shore fisheries production caused by an expansion of shrimp farms and to estimate the economic loss in monetary terms (Suthawan Sathirathai, pers. comm.).

More studies have focused on the on-site pollution of shrimp farms (eg, Briggs and Funge-Smith, 1994, Funge-Smith and Briggs, 1995; Macintosh and Phillips, 1992; MIDAS, 1995; Primavera, 1993; Siri, 1996). The principal water quality parameters for shrimp farms are dissolved oxygen, pH, and the concentration of ammonia (Funge-Smith and Briggs, 1995). The accumulation of organic matter through nutrient leaching from sediments and the high sediment oxygen demand may lead to productivity decreases over time. With the current FCRs of 1.4 to 2.0, about 63-78 percent of the nitrogen and 76-87 percent of the phosphorus in the feed is not incorporated into shrimp tissue, but is lost to the external environment (ibid.).

Many studies conclude that the system of intensive culturing is the major cause of water pollution, outbreaks of disease and consequent production crashes. Pollution in shrimp ponds

either accumulates due to poor pond management (Funge-Smith and Briggs, 1995) or is transported through water and sediment exchange to the coastal environment, and re-enters the pond at some point in time, threatening the long-term sustainability of the sector (Macintosh and Phillips, 1992). Therefore, high quality pond management and an ambient environment of acceptable quality are considered to be the two main criteria for ensuring the long-term sustainability of shrimp farming (MIDAS, 1995).

A number of studies cast doubt on the sustainability of shrimp farming, especially small-scale farms whose operators have little knowledge about systems of sustainable management (Briggs, 1994; MIDAS, 1995). The majority of small-scale farmers have limited education (less than 4th-year primary, NACA, 1996), and no previous training or experience in shrimp farming. Decreasing productivity has been cited as an early indicator of unsustainability of shrimp farming. According to Briggs (1994), shrimp production yield in general has been decreasing at a rate of 3-8% per cycle, mainly because the amount of waste from intensive shrimp farms exceeds the carrying capacity of the environment. It has been suggested that Thailand's shrimp farming has only endured because there exists the possibility for 'shifting cultivation': after years of intensive cultivation, farmers have moved to new locations with a more favourable environment (Briggs, 1994).

Socio-economic impacts

Shrimp farming has fostered economic booms in some regions and contributed to the prosperity of associated industries. It has yielded higher profits than rice farms or small-scale fishing operations. But commercial aquaculture has also had adverse socio-economic impacts on coastal communities. Dewalt et al. (1996) report major conflicts in Honduras between shrimp farmers and fishermen and coastal communities. These conflicts are also present in Thailand, although, perhaps, they are not as open as in Honduras. Briggs argues that: "commercial aquaculture can negatively affect the poor coastal communities, through resource competition, altered familial work patterns, increased unemployment and the degradation of living standards, land and water resources and nutrition" (Briggs, 1994, p.17). He also insists that the economic success of big companies has not trickled down to the traditional users of coastal resources. Small farmers have not benefited from shrimp farming in any significant manner, and indeed tend to be displaced by contract farming. Independent shrimp farmers without the support from big companies do not possess the necessary skills to manage intensive shrimp farms. Briggs: "... In the case of shrimp culture in Thailand, the land used is often owned originally by small-scale rice farmers before being converted into ponds in which to culture shrimp. This culture is occasionally carried out by the farmers themselves, but more frequently the land is either sold or contracted out to entrepreneurs or large businesses, leaving the families to migrate to other areas..." (Briggs, 1994).

Disease

Outbreaks of disease are commonly encountered by all shrimp farmers and are the most critical factor determining farm profits. After laying shrimp seed in their ponds, farmers provide feed, monitor water quality, and check the health of their shrimps daily. Shrimps stay on the pond bottom most of the time, and only swim up in the larval stages to seek food, or on abnormal occasions during adult life. Signs of illness include a change in body colour and the motion of shrimp activity (ASCC News Q1/1990/Issue No.2). Diseases are commonly caused by viruses, bacteria, fungi, protozoa and toxins and are particularly serious in intensive farming areas.

Overstocking and environmental stress are the major causes of disease outbreaks. Overstocking requires greater, and possibly proportionately higher, use of feed especially when the FCR is high. This results in a higher accumulation of waste and reduced oxygen levels which ultimately leads to stress and makes shrimp more susceptible to disease.

Bacteria of the genus *Vibrio* can cause serious production losses in ponds cultured with *P. monodon*. The disease usually occurs one month after stocking. Morbidity and mortality rates range from 5% to 80% within a few days. No successful treatment of the disease has been reported, but good management can minimise the risks.

Among viral diseases the yellow-head disease, caused by yellow-head virus, YHV, and the white spots disease, caused by the SEMB virus, are the most common. Yellow-head disease was first reported in Thailand in 1990 in the Eastern and Central provinces. In the South, its outbreak was first reported in 1992 in Phak Phanang District, Nakhon Si Thammarat province, and it further spread around the Songkhla Lake. There are also abiotic causes of shrimp morbidity and mortality. These include acidic culture conditions, one-month death syndrome, red disease, and brown muscle syndrome.

Antibiotic treatment with oxytetracycline (OTC) is widely recommended for controlling disease, but it seems to have lost its potency due to the emergence of drug-resistant strains (Chalor Limsuwan, presentation at the ASCC meeting, July 1996). Water exchange management to maintain the right concentration of phytoplankton in the pond is also recommended (ASCC News Q1/1991/Issue No.6).

No drug or chemicals are effective in controlling the viruses and therefore prevention is often recommended. Some local firms recommend vaccination of healthy shrimp before stocking (ASCC 1995. Q1/1993/Issue No. 13). Enhancement of host defences through 'immunisation' has been reported in shrimp and other crustaceans (Brock, 1991 and references therein), although more research in this area is necessary (*ibid.*).

In general, disease cannot be entirely prevented, but the risks can be reduced by using good quality seed (postlarvae), good pond management, maintaining an ambient pond environment of acceptable quality, and appropriate stocking densities and maintaining low FCR

Government Responses to Environmental Problems

For the past three decades the Thai government has supported the promotion of shrimp culture, mainly through two agencies, the Department of Fisheries (DoF) and the Board of Investment (BoI). Since the 1970s the DoF has undertaken extension services to promote shrimp farming; BoI has promoted investment projects through support to industry and interim measures during falling shrimp prices or rising energy costs.

In response to the concerns about the environmental impacts of shrimp farming, the government has tightened regulatory policies, particularly those limiting waste and further encroachment of mangrove areas. The Fishery Act B.E. 2490 (1947) requires that fishery enterprises and shrimp farms with an area greater than 8 ha (50 rai) must be registered with the DoF. Violations are subject to a fine (not over 100 baht each time) and/or imprisonment. In 1991 the DoF extended the policy, requiring all shrimp farms to register (Ministerial Announcement, 18 November 1991). Recently, the DoF ruled that fishery enterprises greater than 8 ha must allocate at least 10 percent of their total area to a water treatment pond, that BO from discharged water must not exceed 10 mg/litre, and that sediments must not be disposed in public lands. Some of these regulations are unlikely to have any significant impact as over 86 percent of farms are smaller than 4.8 ha or 30 rai (NSO/DoF 1997) and enforcement of BO standards remains weak.

In response to the loss of mangrove forests, the Thai government has implemented conservation policies. In 1987, a Cabinet Resolution designated three type of mangrove zones: 1) a Conservation Zone, which must be strictly protected; 2) an Economic A Zone, which may be used for exploitation of forest products on a sustainable yield basis (including charcoal production and local uses) and 3) an Economic B Zone, which may be used for other developments in due consideration of environmental impacts (MIDAS, 1995). In 1991, the Cabinet Directive approved a mangrove replanting programme, to be implemented between 1991 and 1996, aimed at planting 50,000 rai (8,000 ha.) of mangroves each year, at a cost of 3,000 baht per rai. In 1993, the Royal Forestry Department (RFD) created a new Marine Park Division to manage coastal resources and to arrest environmental degradation. The DoF recently adopted a policy to limit the area under shrimp production to 80,000 ha or 500,000 rai (Siri Tookvinas, pers. comm. July 1996).

Recently, the Department of Pollution Control (DPC) under the Ministry of Science, Technology, and Environment (MOSTE) commissioned the Network for Aquaculture in Asia-Pacific (NACA) to undertake a study on water pollution from coastal fisheries (NACA, 1996). The Office of Agricultural Economics (OAE) under the Ministry of Agriculture and Agricultural Co-operatives (MOAC) commissioned the Mekong International Development Council (MIDAS) to make recommendations on coastal resource management strategies (MIDAS, 1995).

According to the NACA (1996) study, only 48 percent of shrimp farms (10,542 farms) had complied with DoF registration in 1995 (NACA, 1996, p.145). However, NACA also concludes that DoF's regulatory measures are inadequate for effectively dealing with the environmental problems caused by shrimp farming, and recommends that law enforcement should be strengthened. Specific recommendations include:

- amending the list of poisons to include all chemicals currently used in shrimp culturing;
- that DoF officials may act as the government officials responsible for fishery feed quality. Under the present bureaucratic structure, this regulatory measure is entrusted to the Food and Drug Administration under the Ministry of Public Health. By delegating a regulatory role to DoF personnel, the enforcement of misconduct in industries related to feed, chemicals used by shrimp culturing may be strengthened. This can be achieved through an amendment to the Fishery Feed Quality Control Act, B.E. 2525;
- broadening the definition of government officials responsible for pollution control (Environmental Quality Promotion Act B.E. 2535) to include DoF officials, similarly to tighten monitoring of marine pollution;
- amending the rule for shrimp farm registration, especially farm size;
- limiting shrimp farms to the targeted zone appropriate for shrimp culturing and not to be located near conservation mangrove areas, tourist sites, nor marine national parks.

Similarly, MIDAS (1995) proposed that, due to the extensive mismanagement of coastal resources, government regulatory agencies (notably, DoF, RFD and DLD) should be strengthened. The report specifically proposes a new “Coastal Resource Management Program” costing US\$ 174 million (4.35 billion baht) to be financed from a combination of loan, grant and government funds. MIDAS’ strategy recommendations include:

- promoting R&D in water treatment techniques;
- defining the coastal protected areas;
- designating a shrimp aquaculture area to limit shrimp farming and imposing a tax for shrimp farming outside the zone.
- imposing an export surcharge on processed shrimp and processed shrimp products to vary according to the world price of frozen shrimp; the revenue from the premium to be allocated to the fund;
- establishing a coastal management company to include the government, similar to precedents set by the East Water Resources Management Company, Waste Water Management Company, and Electricity Generating PCL.

Despite attempts by the government to tackle environmental problems seriously, as evidenced by an increased budget and strengthening government agencies concerned with environmental protection, environmental degradation continues.

International Trade

Shrimp exports

Thailand is the world's leading exporter of shrimp, supplying 20 percent of the world trade. Shrimp exports, mainly in the form of fresh or frozen shrimp, account for nearly 70 percent of Thailand's fishery exports which also include frozen fish and frozen cuttlefish. Thailand exports its shrimp in various forms, including fresh (frozen or chilled), dried, boiled and canned. Fresh frozen and chilled shrimp exports account for 60-70 percent of all shrimp exports. Since 1981 Thailand has also been exporting canned shrimp, with market share increasing more than 10% since the late 1980s. A study by Suporn Srisukon (1983) on the marine shrimp industry reports that the cold storage industry in Thailand started in the 1960s with government support through investment promotion; by the early 1980s there were 39 export-oriented cold storage firms. Table 4 shows the expansion of fresh and frozen shrimp exports, in terms of quantity and value (in baht terms) over the 1986-1997 period. The export quantity rose more than 6 times during 1986 to 1994, but fell thereafter, while the export value increased more than 11 times, and after falling in 1996, rose again in 1997 due to the depreciation of the Thai currency.

Table 3: Thailand's Exports of Fresh and Frozen shrimp, 1986-1997

(tonnes, million baht, %)

Year	Volume (t)	% Change	Value (mn. baht)	% Change
1986	28,729		4,391	
1987	33,909	18.03	5,749	30.92
1988	50,431	48.72	9,836	71.10
1989	74,818	48.36	16,197	64.66
1990	85,200	13.88	20,588	27.11
1991	121,864	43.03	26,865	30.49
1992	141,067	15.76	31,875	18.65
1993	149,427	5.93	37,979	19.15
1994	187,436	25.44	49,249	29.68
1995	175,499	-6.37	50,426	2.39
1996 ¹	161,870	-7.77	43,522	-13.69
1997 ¹	137,469	-15.07	47,438	9.00

Sources: Customs Department and Department of Business Economics

Notes: Average growth rate (1986-97) 15% and 24% p.a. for quantity and value, respectively.

¹ Figures for 1996 and 1997 are preliminary.

The major export markets are Japan, the United States, Canada and the European Union (TDRI, 1994). The US is the largest consumer market in the world for shrimps. Shrimps are sold in a large variety of sizes, forms and levels of preparation. In the consumer market, the size of shrimp is usually expressed as the number of individual shrimps per pound (counts per pound), and larger sized shrimps usually fetch better prices than smaller ones. Shrimps are sold shell-on and peeled, headed or not, and at different levels of preparation from frozen, whole shrimp to breaded shrimp for frying, and to complete prepared dinners (Clay, 1996). The largest buyers are restaurants and institutions. Shrimps usually do not have brand names. Consumer preferences vary across the different markets: northern European countries have a preference for cold water shrimp over warm water tropical shrimp; Japanese buyers will pay a premium for Black Tiger shrimp because of its bright red colour when cooked (Clay, 1996). In general, the Japanese market fetches the highest prices for Black Tiger prawns, followed by the USA and the EU, respectively.

Thailand's comparative advantage

Although Thailand competes for markets with other producer countries, its share of world exports is substantial. This might indicate that Thailand has a comparative advantage in shrimp production. Based on 1994 data, Bith-Hong Ling et al. (1996) have calculated the comparative advantage of shrimp exports of eight Asian countries to the Japanese, US, and European markets, respectively. They use the Resource Cost Ratio (RCR) as a measure of comparative advantage. This is a relative measure for the value of domestic resources to be used to earn one unit of foreign exchange. If a country has an RCR of less than one for a particular industry, that country has a comparative advantage in producing and exporting a the produce of that industry. The RCRs for intensively-produced Thai shrimp for the Japanese, US and EU market are 0.19, 0.22, and 0.31, respectively. These RCRs belong to the lowest of eight South and Southeast Asian countries, indicating a comparative advantage for the Thai shrimp industry. It should be noted, however, that this measure does not take account of the environmental costs of shrimp production; whether and how the comparative advantage would change if it did, is unknown and offers an area for future research.

and threats

Bith-Hong Ling et al. emphasise that their measure of comparative advantage is static and does not account for future developments. In the dynamic international market comparative advantages may be easily lost and gained. Acknowledged threats to the comparative advantage of Thailand's shrimp exports are rising production costs, disease, tariff developments, and health and environment concerns in consumer markets. Rising production costs for the shrimp industry in Thailand have been reported, especially for raw material for shrimp feeds and labour (see Mr Phong Wisetphaitun, Manager of Charoen Phokhaphan Animal Feeds Public Co., Ltd., quoted in Manager Daily, 1996). However, more important are the disease epidemics, which have already been discussed, and the threat of increasing trade barriers in the US and the EU.

One of the most immediate threats to the Thai shrimp industry is the recent cut in tariff privileges within the EU under the Generalised System of Privileges (GSP) for Thai fishery, fruit, vegetable and other food products by 50% as of 1 January, 1997. Subsequently, the privileges will be removed totally by 1 January, 1999. The EU decision is based on Thailand's rising per-capita income which has reached the upper limit set by the EU to qualify for the GSP. This will make Thai shrimp products subject to a higher EU import tariff than some competing countries, including Indonesia and especially Ecuador. Tariffs on Thai shrimp will rise from 5 per cent to 8 or 9 percent, and finally to 12 to 13 percent in 1999. (The Nation, 1996).

Consumer markets

Northern consumer concerns with health and the environment are increasing, and foodstuffs are particularly vulnerable. The recent example of the links between Bovine spongiform encephelopathy (BSE) and human health and the subsequent impacts on the British beef industry suggest that it is of vital commercial interest for an industry to maintain the highest possible health standards for its products (Howarth, 1996).

The Thai shrimp industry almost suffered a similar fate when, in the early 1990s, the Japanese authorities discovered antibiotic residues in imported cultured shrimp from Thailand. Faced with an import ban in the Japanese market, the Thai authorities took immediate action, introducing a shrimp farm and processing plant monitoring system to detect and sanction antibiotic residues. The results were spectacular: the plant monitoring revealed that in the first half of 1991 as much as 4.2 percent of the samples contained antibiotic residues. This percentage dropped to 2.1 percent in the second half of 1991, and to zero in the first quarter of 1992 (Csavas, 1992). As it turned out, two-thirds of the processing plants already possessed suitable instruments for detection, but they rarely used them until the antibiotic residues became an issue in international trade (ibid).

Environmental concerns can also have powerful commercial impacts. The recent Brent Spar incident highlights the potential of public influence over a powerful company like Shell to change its policy on the disposal of a North Sea oil platform. Other recent examples of the impact of 'green consumerism' on commercial interests include the US government ban on tuna imports which endangered dolphins. Similarly, in the marine shrimp industry, the US recently banned imports of shrimp caught without "Turtle Excluder Devices (TEDs)" which affected Thai shrimp during 1996. Specifically, the US wants all boats that capture marine shrimp to be installed with TEDs. The US Foreign Ministry announced that in order for shrimp to be eligible for import, the supplier must prove that shrimp are cultured and not captured. In response, the Thai Government teamed up with the Philippines, India, Malaysia and Pakistan to file a complaint to the WTO on the grounds of unfair trade protection. Although the US ban on Thai shrimp exports has since been lifted, the Thai Government is proceeding with the case. (The Nation, 1996).

Health and environment concerns in consumer markets can affect imports in several ways. First, health concerns have given rise to an elaborate system of sanitary regulations for imported foodstuffs into developed country markets. For example, the European regulation affecting fishery products is contained in Council directive¹⁰ 91/493/EEC under the title: “The production and the placing of the market of fishery products” (Commission of the European Communities 1991 OJ L 268). The directive explicitly states that third countries exporting into the EU must fulfil all standards applied to producers within the community. An ‘establishment’ (producer) being eligible for exporting to the European market will need a health certificate issued by the competent authority in the exporting country, stating that all standards in the directive have been met. EU experts may carry out inspections in the third country in order to verify the conditions of production, storage and dispatch of fishery products for consignment to the Union.

The import conditions of fishery products from Thailand have been further specified in Commission Regulation¹¹ 94/325/EC under the title “Special conditions governing imports of fishery and aquaculture products originating in Thailand”. This regulation contains a list of establishments which are certified by the Thai competent body¹². The health certificate accompanying all shipments of cultivated shrimps stipulates that the products were handled and packaged, prepared, processed, frozen, thawed and stored hygienically in compliance with EU requirements; have undergone appropriate health controls; are packaged, marked, stored and transported in compliance with EU requirements; do not come from toxic species or species containing biotoxins, and have satisfactorily undergone the organoleptic, parasitological, chemical and microbiological checks prescribed by the EU.

Second, health and environment concerns may lead to more or less organised consumer boycotts or shifts in demand. Allegedly, a food poisoning incident in Japan in 1996 led to a drop in shrimp imports from Thailand (Manager Daily, 1996). The BSE crisis in Europe led to an overall reduction in beef consumption in the EU of 2.5 percent and a price fall of 14 percent (De Volkskrant 1996). Health concerns of Northern consumers may also have positive implications for the shrimp industry. The trend in developed countries to improve diets with lower cholesterol content has been one of the driving forces in demand shifts of in seafood and aquaculture products (Clay, 1996). On the down side, however, shrimps are very high in cholesterol compared to other seafoods (ibid.).

¹⁰ Directives are binding as to the result to be achieved, but leave to Member States the choice of the form and methods of implementation. That means that they need to be incorporated into national legislation within a certain time limit fixed by the directive itself. That way alliance can be sought with the national political culture, legal traditions, administrative practices, economic structure and environmental circumstances.

¹¹ Regulations are of general application. They are binding in their entirety and immediately have the force of law for all EC subjects.

¹² The Ministry of Agriculture and Cooperatives, Department of Fisheries (Fish Inspection and Quality Control Division), shall be the competent authority in Thailand for verifying and certifying compliance of fishery and aquaculture products with the requirements of Directive 91/493/EEC.

Third, health and environmental concerns may lead to public pressure on the government of the importing country to ban or reduce certain imports. With the rise of the environmentally-conscious consumer in Northern markets, these pressures are likely to become more pronounced in the future. Multilateral trade rules, as governed by the WTO, has put some check on the freedom of governments to bow to public pressures, but governments cannot always simply deny the wishes of their constituents.

Fourth, a more subtle way to meet demands of environmentally-conscious consumers is to supply information regarding all, or a number of the environmental effects of production, consumption and/or disposal of the products. This information can be provided in an 'eco-label' that is rewarded to the "best" products in a certain product category. Eco-labels may be based on a single issue, such as "dolphin-safe tuna", or on an integrated assessment of several environmental characteristics of the product. They may be awarded by governments or by private organisations. In the US, Japan and the EU eco-labelling schemes are expanding and are now the subject of discussion in the Committee on Trade and Environment of the WTO. Although no shrimp eco-labelling initiatives are known at present, it is feasible that they may emerge in the future, especially since mangrove destruction is major issue within Western environmental organisations (eg, Greenpeace). It is worth noting, for example, that Unilever, one of the world's largest fish traders, together with the World Wide Fund for Nature (WWF) is currently examining the feasibility of an eco-label for fish products.

Conclusions

In 1996, exports of farmed shrimp earned Thailand US\$ 2.5 billion, representing about 3.5 percent of its total export earnings. Thailand is now the world's leading exporter and the largest producer of Black Tiger prawns, and supplies 20 percent of the world trade in shrimp and prawn. The rapid growth of shrimp farming in Thailand has led to an economic boom in the coastal provinces of the Eastern and Southern regions and stimulated related industries and businesses, including feed industry, hatcheries, farming equipment, cold storage plants, and processing and export companies.

There are about 26,000 shrimp farms in Thailand, mostly located within a 3-5 km belt along the country's 2,600-km coastline in the Central, Eastern and Southern provinces. About 80 percent of the farms are small, with an area no larger than 1.6 ha. The total area under shrimp farms is estimated to be about 70,000 ha. Farm surveys in Thailand have shown that shrimp farming is a profitable activity, at least in the short term. There is doubt, however, about the longer-term success of individual farms, or, indeed, of the industry as a whole. Shrimp farming can be characterised as a boom-and-bust industry, where income during boom periods has not necessarily 'trickled down' to traditional coastal communities.

Intensive shrimp farming causes negative environmental and socio-economic impacts. In this paper a distinction is made between land use changes and environmental pollution of land and water. Commercial shrimp farming can also have negative socio-economic impacts on coastal communities. Marine shrimp farming has encroached upon about 17 percent (more than 63,000 ha) of the Thailand's mangrove forest area. Environmental pollutants such as nitrogen, phosphorus, suspended solids, chemical and drugs, and antibiotic substances, not only pollute off-site environments, but they also cause on-site pollution, threatening the long-term sustainability of the sector. Decreasing productivity has been cited as an early sign for unsustainability of shrimp farming. It has been argued that shrimp farming in Thailand has endured because of the possibility of 'shifting cultivation': after some years of intensive cultivation, farmers moved to new locations with a more favourable environment.

Overstocking and environmental stress are the major causes of disease outbreaks, a problem commonly encountered by all shrimp farmers and the most critical factor determining farms' profits. The Thai Government has attempted to tackle the environmental problems of shrimp farming, but has not yet succeeded.

The Thai shrimp industry has a comparative advantage in producing and exporting shrimps in the international market, although this paper has identified some threats. Apart from purely commercial developments, such as rising costs and tariffs, the most important threat is the environmental and health concerns of Northern consumers. This paper has presented a number of examples of this trend. If the Thai shrimp industry is unable to respond to these concerns effectively, its future prospects may be bleak. If, however, the industry can move towards more sustainable production, its comparative advantage in the international market could even be enhanced vis-à-vis its less sustainable competitors.

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¹³ Note that for Thai references, we have followed the Thai convention of referring to the author's first name.

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