

# **The Development of Aquaculture in Central Thailand: Domestic Demand versus Export-Led Production**

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*Expansion of aquaculture in Central Thailand since the 1970s is intimately linked to growth in other sectors of the local and national economy, and to participation in global trade. Thailand's agro-industrialization has led to the diversification of agriculture in the Central Region and the co-development of aquaculture. Production of domestic aqua-products is largely positive for consumers, farmers and the environment. By contrast, intensive production of shrimp for export has been characterized by periods of boom and bust resulting from disease outbreaks and international competition. At the farm level this has translated into surges of profit followed by overcapitalization, debt and environmental degradation.*

*Keywords:* Thailand, aquaculture, globalization, domestic markets, agri-business

## INTRODUCTION

Increasing integration into the global economy and associated agrarian and urban-industrial changes have produced optimal conditions for the development of aquaculture in Thailand. This paper places the developmental trajectory of the aquaculture sector in Central Thailand in the context of these economic and historical changes. Although much literature has focussed on Thailand's remarkable economic performance in recent decades and on its once ascendant shrimp industry (with some commentators such as Skladany and Harris (1995) drawing explicit links between the two), few accounts have documented the 'silent' upsurge in fin-fish culture, much of it practised on a relatively small-scale, which has taken place since the 1970s, or have located it in the context of macro-economic change. This paper describes and contrasts in detail the characteristics of aquaculture for domestic consumption and for export, demonstrating that domestic-oriented fish culture, which is typically integrated with other activities,

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offers producers and society at large a number of benefits found lacking in intensive shrimp production for export.

Thailand is the seventh largest producer of aquaculture products in the world, generating some 1.73 million tons in 2004 (FAO 2006). Annual increases in the quantity and value of aquaculture production averaged 10.7 per cent and 15.7 per cent respectively during the 1990s (Piumsombun 2001). Culture of aquatic organisms has become highly developed, dynamic and diverse in nature, especially in the country's Central Region where fish farms account for 58 per cent of national output of cultured freshwater fish and are, on average, more productive and considerably larger than those found in any other region of the country (DOF 2004).<sup>1</sup> Forty to fifty per cent of Thailand's shrimp production is also estimated to occur in low-lying inland areas of the Central Region (Miller et al. 1999). Between February and June 2005 the authors conducted a survey of actors in freshwater aquaculture from nine Central Thai provinces aimed at gaining greater insight into the nature of Central Thai aquaculture and the context of its development. This consisted of 33 semi-structured interviews from one to three hours in length with informants including hatchery owners, feed supply business operators, fish seed merchants, fish and shrimp farmers, and employees of the Department of Fisheries, Bank for Agriculture and Agricultural Cooperatives and Charoen Pokphand (CP, Asia's largest agro-industrial conglomerate). This approach was designed to afford a qualitative overview of drivers of aquaculture development in the region. Interpretation of, and elaboration upon, the information obtained forms the basis of this paper. Part of this research effort included a case study of inland shrimp farming in the district of Ban Sang in Prachinburi province which informs later discussion.

## THE HISTORICAL CONTEXT OF AQUACULTURE DEVELOPMENT IN CENTRAL THAILAND

### *Trade, Industrialization And Urbanization*

The emergence of modern Thailand began with the signing of the Bowring Treaty of 1855 (Hewison 1998). Prior to this time the population had been involved largely in subsistence activities. The treaty established Thailand as an open trading economy (Warr 2001) and linked 'resources rich Siam to the burgeoning global chain of commodity production' (Jackson 2004, 233). Increased rice production was required for trade purposes and numerous canals were constructed in the Chao Phya River delta to distribute floodwaters to paddy fields, expanding the area of cultivatable and habitable land (Takaya 1980). The second half of the nineteenth century was thus a period of international integration for Thailand,

<sup>1</sup> Central Thailand is comprised of 26 provinces including Bangkok. The region covers approximately 25 per cent of the country's surface area and is home to approximately 25,000,000 people, just under 40 per cent of the national population (NSO 2002).

characterized by the gradual commercialization of agriculture, development of businesses focussed on the export trade, increasing interactions with foreign powers and businesses, monetarization of the economy and the influx of Chinese merchants and workers (Hewison 1998). Fish culture began in the early twentieth century when Chinese immigrants in the Bangkok area imported fry for the purpose of establishing Chinese-style carp polyculture systems (Edwards 2004).

Following the Second World War, Thailand took advantage of the opportunity to stimulate trade by increasing rice exports in response to global food shortages. The Chainat flood control dam was constructed during the 1950s along with a complex system of drainage canals to distribute the impounded water, opening up more land in Central Thailand to agricultural production and settlement. Improved irrigation allowed for practices such as double cropping of rice and stimulated agricultural intensification in the region. At this time the principal source of fish protein for the inhabitants of Central Thailand was the floodplain fisheries of the Chao Phya River and its tributaries (Edwards et al. 1983). An unfortunate consequence of improved irrigation and flood control was the widespread destruction of wetland habitat and a decline in the productivity of the inland fishery. However, the stabilization of water supplies and diminished harvest of wild fish provided conditions in which widespread aquaculture became viable, and corresponded with its emergence as an increasingly important activity from the mid-1960s (Belton et al. 2005).

In more recent decades, globalization – ‘the effective erasure of national boundaries for economic purposes’ (Daly 1999, 31) – has emerged as a dominant force as economic transactions, activities and investment have expanded across national and political borders in a markedly accelerating process, and many countries have attempted to pursue rapid integration into a single global economy as a development strategy (Nayyar 2003). Successive Thai governments have committed the country to increasingly open trade and investment regimes, which have generated remarkable development and rates of growth in many sectors (BIT 2003; Dollar and Kraay 2001). From the 1960s onwards, increases in agricultural production and exports helped expand national income and government revenues, generating capital surpluses that supported investment in manufacturing (Ichikawa and Cusumano 1992). An import substitution industrialization strategy was pursued, aimed at expanding manufacturing by increasing incentives such as tariff protection for domestic and foreign investors. Although successful, the strategy was replaced by one of export-oriented industrialization in the late 1970s as a result of a number of factors, including the decline in international agricultural commodity prices (Hewison 1998).

Export-oriented manufacturing has made a particularly important contribution to Thailand’s economic development, with average annual growth in manufactured exports averaging over 16 per cent per annum during the 1980s. Foreign direct investment has played an important role in the growth of industry and commerce, often in the form of joint ventures (Hewison 1998). The contribution of industrial output to GDP has risen from 13 per cent in 1960 to 45 per cent today (Pradhan 2003). However, although agricultural output also increased rapidly

during the early phase of industrialization,<sup>2</sup> the rate of agricultural growth and the relative contribution of agriculture to GDP has since fallen considerably. While more than half the population remains employed in agriculture, the sector now contributes less than 10 per cent of total GDP (MRC 2003a). These fundamental changes to the structure of the economy resulted in growth averaging close to 8 per cent per annum for the 30 years preceding the Asian financial crisis of 1997 (MRC 2003b). Standards of living, per capita incomes and indicators of development have all improved dramatically since the 1970s, particularly in Bangkok and its surrounding provinces, and a substantial infrastructure including excellent road and communications networks has been established (NSO 2002; BIT 2003).

Bangkok was the centre of Thailand's early industrialization. Pradhan (2003) states that real daily wages in industry rose from Bt108.18 (\$2.63) in 1977 to Bt206.46 (\$5.01) in 1995, while real daily wages in agriculture stagnated at Bt63.99 (\$1.55) until 1993. As a result of rural–urban wage disparities, huge numbers of seasonal and permanent rural migrants were attracted to work in newly established industries in and around Bangkok, and the city's population rose from 4.5 million in the late 1970s to more than 10 million today.<sup>3</sup> The influx of migrants generated pressures on land use including rising land prices and serious congestion, leading to the subsequent establishment of new industrial facilities and residential areas along arterial roads and canals leading out of the city and the rapid urbanization of surrounding provinces (Pakkasen et al. 1978). This industrialization and urbanization, and the associated growth of a class of relatively affluent urban consumers, has spurred demand for aquaculture products and provided increased levels of income with which to purchase them (Little and Edwards 1999; Rae 1998).

#### *Institutional Agents for Aquaculture Development*

Rigg and Nattapoolwat (2001) note that much of the dynamism in rural areas of Thailand has been independent of government policy. This is true of most Central Thai aquaculture, evolution of which has been relatively organic – driven to a large degree by farmers' utilization of available resources and the informal dissemination of knowledge by observation and word of mouth. Interventions by various institutions including universities, NGOs, overseas development agencies and government departments have shaped the developmental trajectory of aquaculture, however. Of these, the Department of Fisheries (DOF) has played the most significant and influential role. DOF has pioneered and disseminated a number of techniques that have been widely adopted, introduced

<sup>2</sup> Thailand was the only major net exporter of food in Asia in the late 1970s (Pakkasen et al. 1978). It remains a major agricultural producer and the fifth largest exporter of agricultural commodities among developing countries (Buch-Hansen 2003).

<sup>3</sup> Monthly household incomes in Bangkok are at least twice the national average; Bt28,239 (\$686) in comparison to Bt13,736 (\$334) in 2002 (NSO 2004).

new strains and species of fish, and provided support, training and extension to aquaculture producers, all of which has contributed to gains in aquaculture production.<sup>4</sup> Another state institution, the Bank for Agriculture and Agricultural Cooperatives (BAAC) has been critical to the development of agriculture and aquaculture, and delivers credit on terms tailored to the operational needs of farmers to approximately 77 per cent of all households in the agricultural sector (FAO 2004).

Agro-industrial corporations, in particular the Charoen Pokphand Group (CP), have also made major contributions to aquaculture development. This Thai-owned business is the country's largest conglomerate, with a total turnover 1995 in excess of \$4 billion and with 100,000 employees in 20 countries (Goss et al. 2000). Marketing of livestock feeds in Thailand is extremely competitive and has driven the development of contract farming and other vertically integrated farming systems by feed companies. CP introduced and adapted contract farming systems for broiler chickens, allowing it to expand sales of formulated feeds (Falvey 2000). The growth of this activity has facilitated the co-expansion of integrated chicken–fish farming. Development of formulated feeds for livestock has also enhanced the development of aquatic feeds, of which CP manufactures a comprehensive range, as part of a cost-effective diversification strategy. Use of formulated feeds in aquaculture remains highly species specific, however, and mediated by the range of alternative opportunities open to farmers. CP is also an industry leader in shrimp production as a producer, feed manufacturer, processor and exporter, and has played an extremely significant part in the development of shrimp production since the early 1980s.

## INTEGRATED AQUACULTURE

### *Integration*

The following sections detail the growth of integrated aquaculture in Central Thailand and its linkages with other sectors of the economy. The vast majority of Thai freshwater fish production involves some degree of integration. Integrated fish farming links aquaculture with other human activity systems in order to capitalize on their by-products. It is defined by Edwards (1998, 5) as 'concurrent or sequential linkages between two or more human activity systems (one or more of which is aquaculture), directly on-site, or indirectly through off-site needs and opportunities, or both'. Organic wastes generated by agricultural

<sup>4</sup> DOF developed breakthrough artificial spawning techniques for numerous fish species and introduced and disseminated Chitralada1 and GIFT strains of tilapia, the uptake of which has been extremely far-reaching among hatcheries and farmers and contributed to increasing aquaculture production. Fifty-seven DOF-run Provincial Fisheries Stations produce seed fish, offer support, extension and technical advice to fish farmers, conduct research and training, and collate fisheries data. Certain Fisheries Stations, e.g. Nakorn Sawan, have had a major impact on local and national aquaculture development, pioneering new techniques which have been rapidly adopted by local producers.

production and processing activities are extremely widely utilized as low-cost feeds and inputs for fish culture in Central Thailand. Because of their potential applications, Taiganides (1979, 1) instructively suggests that ‘wastes [of this kind] are resources out of place’.

Directly integrated systems utilize resources (wastes) produced on-site. In Central Thailand direct integration typically takes the form of livestock/fish culture in which intensively reared chickens or pigs are housed over or next to fish ponds. Manure and spilt formulated feed fall into the ponds where the nutrients are sequestered in fish production. Manure acts as a fertilizer, stimulating blooms of algae which are consumed by filter feeding fish. Spilt animal feed provides a supplementary source of food, and stocking species in polyculture maximizes the efficiency of nutrient use. Fish species raised in this way are normally either herbivorous or omnivorous (e.g. Nile tilapia – *Oreochromis niloticus*; silver barb – *Barbodes gonionotus*; rohu – *Labeo rohita*; and silver striped catfish – *Pangasianodon hypophthalmus*). Indirectly integrated systems utilize low-cost resources produced off-site for the same purpose. Leftover food from restaurants and factory canteens, rice bran and broken rice, noodle waste, waste bread, pig and chicken manure, *ami ami* (a byproduct of monosodium glutamate processing), and many other agro-industrial by-products are commonly employed as fertilizers and supplementary feeds by fish farmers in the region. Carnivorous fish are also raised intensively in indirectly integrated systems; hybrid walking catfish production in Central Thailand is heavily dependent on the by-products generated by processing chicken for export, and snakehead (*Channa striata*) culture is reliant on supplies of trash fish landed or processed by the canning industry at ports on the upper Gulf of Thailand.<sup>5</sup> The nutrient-rich effluent from intensive pond production of these species may also be used as an input into polycultures of lower trophic level fish such as tilapia and carps.

#### *Agriculture, Aquaculture, Growth*

Economic growth and urbanization increase off-farm employment opportunities, raising the opportunity cost of working in the agricultural sector. Urbanization and trade liberalization also trigger demand for food and agricultural products as incomes rise, enabling a shift of consumer demand from staple foods (e.g. rice) toward higher value goods such as meats, fruits and vegetables. At the farm level operations become more specialized, intensive and commercial in nature in order to participate in the market, and to adjust to its opportunities and demands, while at the national level agricultural production becomes more diversified (Pingali and Rosegrant 1995). Other things being equal, irrigated lowlands such as those of Central Thailand are more easily commodified than other agro-ecosystems

<sup>5</sup> Trash fish is divided into two categories; high quality trash fish is normally bycatch from marine trawling for other species, although small fish not normally used for human consumption are sometimes deliberately targeted. Poor quality trash fish is comprised largely of waste, e.g. fish heads and bones, from Thailand’s large canning industry.

because they can generate larger material surpluses (Falvey 2000). Commercialization of agriculture in these rice-monoculture dominated areas has led to the introduction of specialized enterprises such as horticulture, aquaculture, poultry and pig production (Molle and Srijantr 1999). Table 1 reflects these changes.

The greatest concentrations of pigs and poultry in the country are found in the provinces around Bangkok (Falvey 2000). Rice, fruit and vegetable production are also more intensive and productive in the Central region than any other part of the country (FAO 2004). Food processors have been able to capitalize upon the abundance of high quality local raw materials, and the processing industry's productivity has continually increased in response to strong exports and a growing and diversified domestic market (DTC 2005). Raw agricultural products accounted for 80 per cent of all Thai exports in 1980, but by the mid-1990s represented only 30 per cent, with processed foods increasing to 30 per cent of manufactured exports (McMichael 1996). Edwards (1998, 4) notes that 'crop processing provides rice bran and oil cakes; animal processing provides entrails, blood and bone from slaughterhouses . . . food manufacturing provides diverse organic residues; and the residues from breweries and distilleries are frequently used as fish feed'. The resources generated by these activities are significantly cheaper than commercial aqua-feeds, meaning fish raised in integrated systems can be sold at very low cost relative to those produced by farmers reliant on the use of formulated feeds. It is due to this confluence of factors that fish farms in the Central Region generate 58 per cent of national output of cultured freshwater fish (DOF 2004).

Figure 2 illustrates the interaction between several of the key factors outlined above which have shaped the growth of integrated aquaculture in Central Thailand. Industrialization has boosted trade (Hewison 1998), which has in turn stimulated further industrialization. A similar positive feedback relationship exists for trade and increasing, intensified and diversified agricultural production. Finally, a link also exists between agricultural production and the industrial processing of agricultural goods for export. These three aspects of Thai participation in the global economy have generated a range of effects which have been particularly pronounced in Central Thailand and key to the development of its integrated fish culture: industrialization has been responsible for migration to, and urbanization of, the provinces surrounding Bangkok (Greenberg 1994); increasing trade has generated increasing income levels (Dollar and Kraay 2001); and increased, intensified agricultural production has generated large quantities of cheap resources ideal for fish culture (Belton 2006).

Fish has always been the primary source of animal protein in the Thai diet and cultural attachment to it as a food source is very strong (ADB 2005). Bangkok's huge and growing population has therefore generated demand which can only be met by aquaculture, since city dwellers are unable to capture fish from the wild and traditional inland fisheries generate insufficient catch. In addition, the increasing wealth of the urban population has meant that it consumes progressively greater quantities and alternative varieties of fish products (Piumsombun 2001). The existence of this growing market coupled with low-cost resources generated by

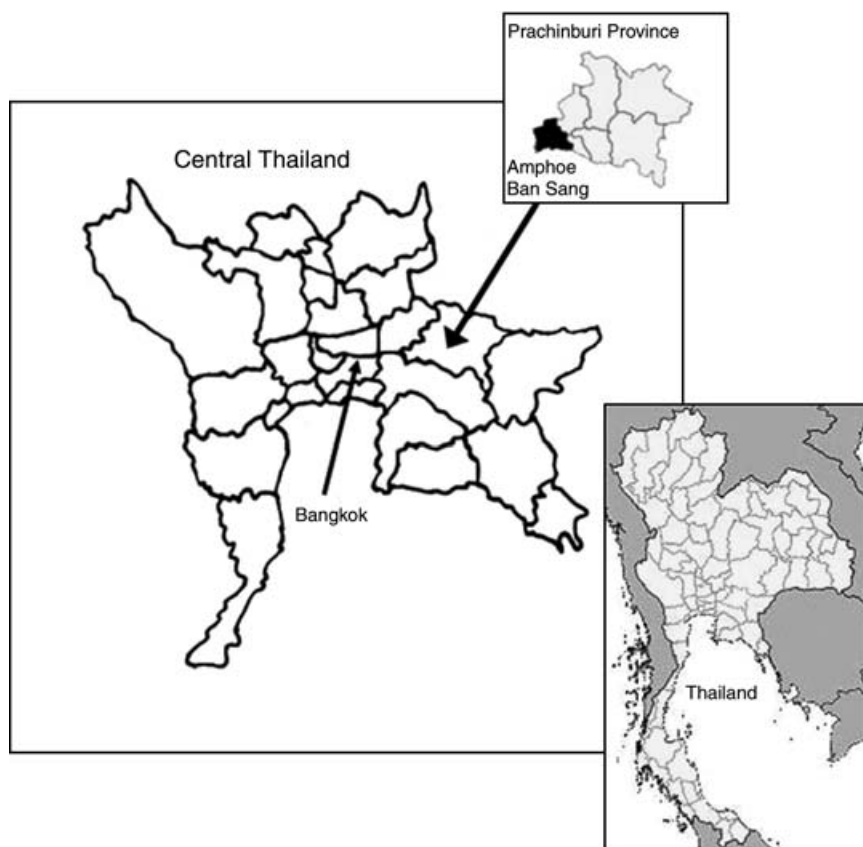
Table 1. Agricultural production for selected commodities in Thailand, 1961–2005

Crop	Year						% Change
	1961	1970	1980	1990	2000	2005	1961–2005
Freshwater fish	7,194	19,829	34,646	97,659	271,012	404,706	5,626
Rice	10,150,000	13,850,000	17,368,096	17,193,216	25,844,000	29,201,000	288
Chicken	82,000	196,000	287,000	575,000	1,091,000	950,000	1,159
Pig	129,067	210,000	267,000	337,500	474,670	686,969	532
Fruit and vegetables	3,447,387	4,658,106	9,972,321	8,792,589	10,920,569	11,419,077	331

Source: Modified after FAO (2007a, 2007b).



Figure 1 Central Thailand

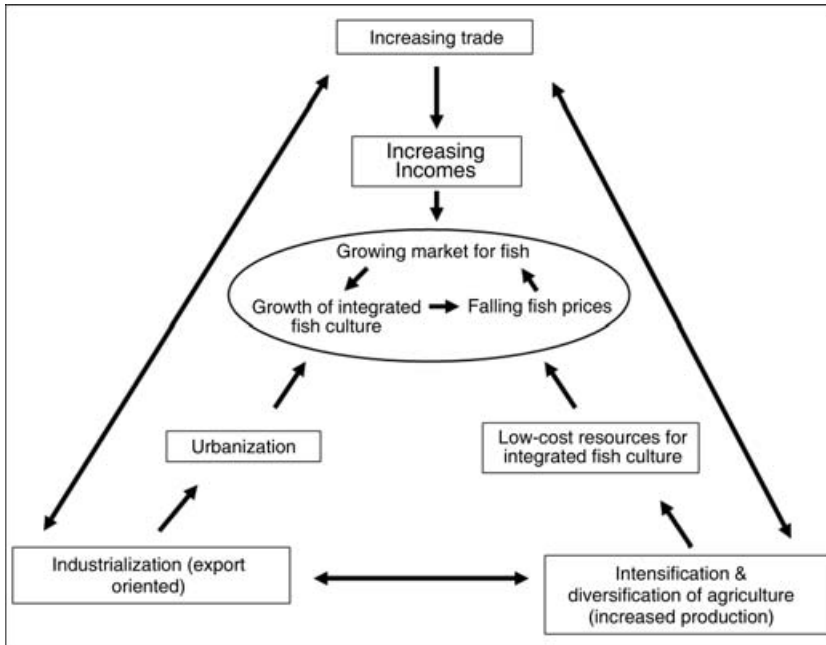


agriculture and food processing has given rise to large increases in fish production. As the supply of cultured fish produced in integrated systems has increased, adjusted prices for most fish species have fallen year on year. This has stimulated greater consumption of these products, pushing down prices and increasing demand further. The falling prices of fish products have caused producers to seek greater efficiencies which they have been able to achieve due to concurrent intensification of the livestock sector, increases in the size of livestock and fish production units, and constantly improving access to markets. It is this downward pressure on prices, represented at the centre of Figure 2, that has been responsible for the scale of the boom in fish-production since 1990 (Belton et al. 2005).

#### *Hybrid Walking Catfish Culture*

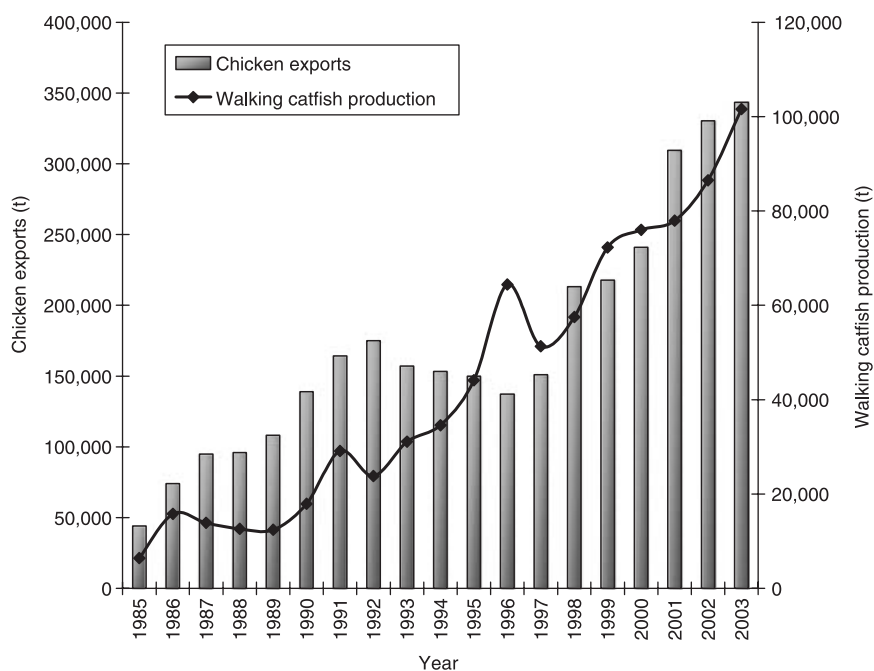
The history of walking catfish culture provides a clear-cut example of how aquaculture has benefited from agro-industrial linkages and restructuring. Prior

Figure 2 Interaction of factors influencing the growth of integrated agriculture in central Thailand



to the late 1980s, culture of walking catfish was mainly limited to the Thai species *Clarias batrachus*. Hybridization of another native, higher value catfish with an imported African species produced the hybrid walking catfish (*C. macrocephalus* × *C. gariepinus*) which is easier to culture and quicker growing than *C. batrachus*. Although this advance undoubtedly contributed to the growth of walking catfish production since 1990, the growth of chicken farming, particularly for export, was also critical. Early walking catfish farmers were dependent on trash fish as feed, and production was therefore confined to sites close to the Gulf of Thailand. Chicken by-products (in particular viscera, leg bones and heads) provide a cheaper alternative feed which is available throughout most of the Central region. Around two-thirds of the chicken produced in Thailand is consumed domestically but by-products from these birds are widely dispersed and available only in small quantities, and therefore of little use to catfish farms which can require several tons of feed each day. Almost all chicken produced for overseas consumption, however, is exported in boneless form and an estimated 62 per cent of its live weight remains in the country as meatless carcass, bone and offal, much of which can be utilized as catfish feed (Little et al. 1994). Hybrid walking catfish may also be raised on commercial formulated feeds but chicken by-products are significantly cheaper, affording farmers in Central Thailand with access to them a comparative advantage. Figure 3 illustrates the upward trend in walking catfish production which closely parallels increases in exports of chicken meat.

Figure 3 Walking catfish production and chicken meat export 1985–2003



Source: DOF (2005), FAO (2007b).

*Producers, Consumers and the Environment*

The concentration of intensive livestock production and processing in peri-urban areas generates volumes of waste too large to be used as traditional land fertilizers or too costly to transport. Integrated aquaculture therefore provides a space-efficient means of treating potential pollutants whilst accruing economic and social benefits (Little and Edwards 1999). With reference to hybrid walking catfish production, Little et al. (1994, 27) suggest that ‘income from byproduct sales is important in the chicken industry with its small profit margins and competition with lower-cost producers such as those in China. The value of by-products sold can be equivalent to 90 per cent of labor costs or 40 per cent of transport costs of broiler production’. They conclude that the ‘relationship between an export-based food industry and fish culture producing food for the domestic market increases employment opportunities’ (ibid., 27).

Thailand’s rice farmers are facing increasing pressure and declining profitability in the face of competition from very low-wage rural economies such as India and Vietnam (Flaherty et al. 1999). Around half of the farmers interviewed who practised integrated aquaculture had formerly grown rice, and unanimously

considered fish culture a more profitable and sustainable livelihood. This represents a departure from the situation in the 1970s and early 1980s when integrated aquaculture in the Central region was dominated by ethnic Chinese entrepreneurs (Edwards et al. 1983), and indicates the degree to which access to knowledge, markets, capital and credit has grown. Crucially, both the relatively low cost of market entry for integrated fish farmers and the low unit value of fish raised in these systems mean that integrated aquaculture benefits not only farmers but poor consumers (Edwards 1998).

## SHRIMP FARMING

### *Overview*

Modern integrated aquaculture in Central Thailand has emerged as a result of interactions between the local and global economy but generates a range of broadly positive effects not commonly identified in critiques of globalization. By contrast, intensive shrimp culture seems a paradigmatic example of the export-oriented agricultural specialization in high value non-traditional crops associated with the globalization of food commodity chains (Hall 2004), and exhibits many problems frequently identified as outcomes of this process. Ninety per cent of cultured Thai shrimp is destined for export to developed countries, in particular Japan and the United States, and the crop represents a significant source of foreign exchange earnings for Thailand, generating approximately \$2 billion in export revenues in 2000 (Yap 2001). Unlike integrated aquaculture, shrimp farming has become dependent on commercially manufactured feeds and is capital and management intensive (Pongthanapanich 1999). Thai shrimp production is dominated by ten companies with feed manufacture and post-harvest marketing operations that exhibit an extremely high degree of vertical integration. The CP Group is the largest of these, commanding 65 per cent of the shrimp feed market (Goss et al. 2000). Shrimp culture is a high risk, high return enterprise. Shrimp farmers realize average annual returns on successful crops approximately ten times greater than those of rice farmers producing two crops a year, but small farms can be bankrupted by a single crop failure or two consecutive poor crops because of high operating costs (Pongthanapanich 1999). Until recently, Thailand was the world's largest exporter of farmed shrimp, contributing around 25 per cent of global output, but it has now been dramatically surpassed by China, with Vietnam also gaining substantial ground (FAO 2007b).

### *Inland Shrimp Culture*

Culture of black tiger shrimp (*Penaeus monodon*) in coastal provinces began to expand rapidly in the mid 1980s, catalyzed by transfer of technology from Taiwan. A catastrophic disease outbreak in Taiwan caused the collapse of its shrimp industry and CP, in partnership with Mitsubishi, began to introduce Taiwanese shrimp culture techniques to Thailand with the support of institutions including

DOF and the Asian Development Bank. These efforts enabled the intensification of the traditional extensive shrimp culture which been practised in the provinces on the upper Gulf of Thailand for decades (Skladany and Harris 1995). Production boomed, increasing from 13,007t in 1984 to 265,524t in 1994 (FAO 2007b), utilizing large areas of coastal land and generating a well documented range of undesirable environmental consequences (e.g. Naylor et al. 1998). Farm failures also began to increase during the 1990s as declining yields and disease outbreaks emerged, aggravated by factors including self-pollution (e.g. intake of effluent released from nearby shrimp farms) and poor management. As a result, more than 80 per cent of operations on the lower Chao Phya Delta were abandoned within a few years of being established (Szuster 2003). Exhaustion of suitable coastal sites and the desire to relocate away from disease-prone areas prompted producers on the upper Gulf of Thailand to move away from the coast into brackish water areas along the Chao Phya River. Black tiger shrimp are able to tolerate large variations in salinity and innovative hatcheries later managed to acclimatize shrimp post larvae<sup>6</sup> to very low salinity conditions, allowing them to be raised even further inland in completely freshwater areas (Szuster 2006). The true extent of inland shrimp culture is unclear but it is likely that approximately 40–50 per cent of Thailand's production now occurs in areas removed from the coast (Miller et al. 1999). The following section draws on our survey of inland shrimp culture in the Ban Sang district of Prachinburi province to examine the impacts of this global industry at the local level.

### *Shrimp Culture in Ban Sang*

Shrimp farmers in the coastal province of Chachoengsao were early adopters of low salinity shrimp farming techniques. These proved successful and highly lucrative, and farmers and investors seeking to expand operations introduced them to neighbouring Prachinburi Province in 1990–1991. Initially these individuals rented rice paddies in the Ban Sang district, employing the landowners to tend ponds. Local residents rapidly adopted the activity having observed the success of these pioneers. According to respondents in Ban Sang a high proportion of inland shrimp producers farmed rice prior to adopting the activity. The attraction of shrimp farming for rice farmers is clear. Szuster et al. (2003) surveyed shrimp and rice farms in Nakorn Pathom, finding that the average annual net income per hectare from shrimp was \$6,030; nearly ten times more than the average annual net income per hectare of rice at \$620. The risks entailed become apparent when costs are examined, however. Fixed costs per hectare for shrimp are an estimated \$788, compared to \$193 for rice. Estimated annual operating costs are \$172 ha for rice and \$14,000 ha for shrimp.

<sup>6</sup> The term 'post larvae' refers to the stage of development at which shrimp juveniles are stocked, by which time they are no longer in the larvae, but still lack some of the characteristics of juvenile shrimp.

High farmgate prices for black tiger shrimp of up to Bt500 (\$12.14)/kg in the early to mid 1990s made it possible for small farms to achieve extremely high profits. As a result, start-up capital for shrimp ventures, either as loans from BAAC or from informal sources, was easy to secure. Investment in feed (which accounts for around 50 per cent of production costs) was heavy, but local feed dealerships, usually franchises of major feed manufacturers, would provide regular customers with feed and other inputs on credit as excellent yields and high prices allowed repayment in full upon harvest. Goss et al. (2000) note that during this period 80 per cent of Thai shrimp farmers purchased feed on credit, making them vulnerable to future disease events and market fluctuations. Large numbers of small-scale independent farmers made unprecedented returns on their investments. Although numerous individuals operating in this way experienced major financial gains, agro-industries transferred profits (economic surplus) away from rural areas, concentrating them in Bangkok and other trading centres, meaning that urban investors ultimately profited more from shrimp farming activities than farmers themselves (Buch-Hansen 2003).

The expansion of black tiger shrimp production in Ban Sang, spurred by high returns and access to credit, peaked in 1995–1996 after a five-year boom phase. During this period the area experienced significant localized economic growth. New businesses such as shops and restaurants, and ancillary services such as feed dealerships, opened in and around the town and land rental values increased substantially. This developmental trajectory contrasts markedly with that of integrated aquaculture in the area, which has grown far more steadily. (Fish farms in Ban Sang are less geographically concentrated, more diverse in nature, are serviced by far fewer ancillary businesses, and generate modest returns relative to shrimp.) Successful shrimp farmers tended to overcapitalise, expanding their operations in the expectation of continuing high prices and favourable culture conditions. From 1996 to 1998 the productivity and profitability of most operations began to fall. Interviewees all made reference to perceived declines in the quality of broodstock and post larvae at this time, noting that post larvae survival rates fell to below 50 per cent and shrimp growth rates slowed. This extended production cycles and drove up operating costs. Although not always acknowledged by farmers, poor management practices such as overstocking were undoubtedly major contributing factors to this declining performance. Falling productivity was further compounded by the emergence of disease problems which had hitherto made little impact in the area.

The combined output of the major shrimp producing countries has steadily increased (Tables 2 and 3). Increasing competition from international producers has placed additional pressure on farmers in the region. Ling et al. (1999) observe that trends indicate significantly increased competition in world shrimp markets, with many countries initiating or expanding shrimp culture; that oversupply of cultured shrimp products has occurred since the early 1990s and that, consequently producer prices have dropped and profit margins for farmers have been squeezed in export markets. This situation is deeply problematic for many producers given that a 10 per cent drop in the farmgate price of shrimp can result

Table 2. Farmed black tiger shrimp output (t) by major producing countries, 1996–2005

Country	Year									
	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Vietnam	34,595	33,918	38,977	41,176	67,486	111,095	126,416	150,000	185,569	177,200
India	64,400	60,925	76,900	73,700	90,975	97,100	108,990	108,680	127,802	142,070
Indonesia	96,237	96,317	74,824	92,726	90,483	103,603	112,840	132,761	131,399	134,682
China	–	–	–	–	–	–	–	51,086	60,579	75,731
Thailand	235,875	223,551	247,458	271,019	304,988	274,330	200,574	194,909	106,884	75,000
Total	431,107	414,711	438,159	478,621	553,932	586,128	548,820	637,436	612,233	604,683

Source: FAO (2007b).

Table 3. Farmed white shrimp output (t) by major producing countries, 1996–2005

Country	Year									
	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
China	–	–	–	–	–	100,000	200,000	605,259	735,055	808,433
Thailand	–	–	–	–	–	–	60,000	132,365	251,698	299,000
Indonesia	–	–	–	–	–	–	–	–	53,217	103,874
Vietnam	–	–	–	–	–	–	10,000	31,717	40,000	100,000
Mexico	13,315	17,422	23,749	29,120	33,480	48,014	45,853	43,857	62,361	72,279
Brazil	3,364	3,613	7,254	16,054	25,388	40,000	60,000	90,190	75,904	63,134
Ecuador	97,920	119,439	129,600	107,700	50,110	45,269	46,735	55,500	56,300	56,300
Total	114,599	140,474	160,603	152,874	108,978	233,283	422,588	958,888	1,155,874	1,374,441

Source: FAO (2007b).

in a 73 per cent fall in income for farmers (Goss et al. 2000). Furthermore, farms receiving the highest prices are usually those with the highest levels of capital security (e.g. those run directly by CP), whereas those operating at the margins of profitability are least able to ride drops in price or crop losses due to disease, especially if feed is purchased on credit (Goss et al. 2000). Israngkura and Sae-Hae (2002) also note that shrimp processing and exporting companies are able to guard themselves better against economic losses than farmers, and take a smaller share of national disease-induced loss. The imposition of public health based trade restrictions by markets such as Japan and the EU in response to contamination of shrimp with high levels of chemical therapeutants has placed further pressure on small-scale farmers. Declining productivity and export values during 1996 and 1997 had major impacts in Ban Sang. High production costs were no longer offset by high farmgate prices and failure of a single crop frequently caused farmers to default on loans, most commonly to dealerships that had supplied feed on credit. Although the total number of shrimp farms in the Ban Sang district has remained fairly constant since the mid 1990s at between 2000 and 2500, production has been cut back as farmers have reduced their exposure to risk by stocking only a proportion of their ponds. Shrimp feed sales in Ban Sang for 2004 were around a third of what they were in 1996, an estimated 20 per cent of failed shrimp farmers in the area have had to sell land to repay debts, and the BAAC and feed dealerships will no longer provide credit to shrimp ventures.

The South American white shrimp (*Litopenaeus vannamei*) was introduced to Ban Sang in 1999, and many black tiger shrimp farmers who were experiencing difficulties switched species, giving rise to a second brief boom in 2002 in white shrimp. As with black tiger shrimp, farmgate prices were again initially high enough to generate substantial profits, and culture cycles were short, but by 2003 almost identical problems related to poor post larvae performance, extended culture periods, disease and depressed prices were again evident. The decline in white shrimp prices is in part attributable to rapidly growing domestic production as farmers switched from black tiger shrimp culture. China's entry into white shrimp production in 2000 and Vietnam's in 2002 will also have contributed to falling international prices (Table 3). Profit margins for both species are now extremely slim, as production costs such as feed and fuel have risen, culture periods have lengthened by 60 per cent or more, and per unit productivity and farmgate price have dropped. Although disease problems remain pervasive and reduced growth rates are almost universal, interviewees indicated that careful and adaptive management could reduce their likelihood and severity. Indeed, much poor management of farms that occurred in the past can be attributed to practices of short-term profit maximization (e.g. stocking post larvae at extremely high densities and excessive use of drugs). Depressed market price is the overriding difficulty at present however, with financial losses possible even given production of successful crops, and interviewees painted a gloomy picture of an uncertain future for small and medium scale inland shrimp culture.



*Environmental Issues*

Like its coastal counterpart, inland shrimp culture has attracted severe criticism for its environmental impacts. Acclimatization of post larvae to freshwater requires inputs of concentrated seawater at the start of the production cycle. Seepage of this saline water from shrimp ponds has the potential to seriously degrade rice paddy (the most common use of land in inland shrimp farming areas) (Szuster 2006). Large volumes of freshwater are also required to maintain water quality in ponds, leading to competition for water in some areas, again, particularly with rice farmers (Flaherty et al. 2000). Less than one-sixth of the nitrogen and phosphorous available from feed is assimilated as shrimp body mass (Thakur and Lin 2003) and this organic waste acts as a pollutant when discharged into waterways at harvest time. Overuse of antibiotics and other chemo-theraputants has also been widespread, giving cause for concern (Flaherty et al. 2000). Naylor et al. (1998) criticize intensive shrimp culture as a whole for its inefficient use of fish meal and fish oil in its feeds. They also note that the lifespan of intensive shrimp ponds is short and that conversion of degraded pond areas to other agricultural uses is often economically unviable. By contrast, integrated aquaculture can improve overall efficiency of nutrient use in farming systems, compensate for relative inefficiencies in nutrient use by livestock by recycling for fish production, and reduce levels of effluents (Little and Edwards 2003).

## CONCLUSION

This paper has sought to demonstrate that development of aquaculture in Central Thailand has been inextricably linked to changes in the Thai economy and Thailand's economic relations with the world. The nation's transformation into an agro-industrialized economy, and the economic growth that has accompanied this change, have been mediated by its increasing integration into a single global economy. All current forms of Thai aquaculture can therefore be seen partially as outcomes of, and reactions to, this ongoing process. For domestic-oriented aquaculture, the resultant industrialization and urbanization of Bangkok and the surrounding provinces has generated a huge domestic market of often relatively affluent consumers, which is easily accessible to fin-fish producers in the Central Region. These producers have been able to capitalize upon the resources made available by the region's high agricultural productivity and the processing of agricultural goods. The large quantities of low-cost resources yielded by agro-industrial activities are exploited in integrated aquaculture and facilitate low-cost fish production; a feature which is advantageous both to those who adopt the activity and those who consume fish. For these reasons, given continued growth in other sectors of the economy, aquaculture for the domestic market (perhaps including new forms of corporately developed higher-value intensive aquaculture) has potential for continued and sustainable expansion.

Economic interactions between the Thai and global economies and the changes these have engendered have created structural precursors for aquaculture

development in the Central Region. In many instances these interactions are also immediate in their impacts on aquaculture development (e.g. where exports of boneless chicken provide the basis for expanding hybrid walking catfish production). Although the developmental trajectory of fish culture has been influenced by agents including the Department of Fisheries and major companies, it is largely entrepreneurial producers and other actors in the marketing chain who have pushed the activity forward by exploiting resources as they have become available, by adopting and disseminating new technical advances, and by responding to changing markets. Integrated fish culture is therefore a culturally appropriate activity for Thailand, fitting well into both the rural and urban landscapes of production and consumption and capitalizing upon existing capabilities and needs.

The model for intensive shrimp culture is markedly different in its organization of production and socio-economic implications. Whereas integrated aquaculture has flourished for the reasons outlined above, intensive shrimp culture developed for a very different set of reasons. The nature of the corporately organized, vertically integrated production system means that although farmers are nominally independent, their livelihoods are vulnerable to both local pressures such as disease and external factors such as international competition, and that they have limited flexibility in their production strategies. As a result, the livelihoods of small and medium-scale shrimp farmers are less resilient in the long term than those of integrated fish farmers despite having (until recently, at least) the potential to generate far greater financial returns. Inland shrimp culture is also far less ecologically sustainable because its intensive, extractive use of resources is effectively de-linked from other agrarian activities. A number of outcomes of the globalization process are, either directly or as a result of interaction with local factors, responsible for the variety and scale of aquaculture in Central Thailand. Both sustainable integrated fish culture and unsustainable intensive small-scale inland shrimp culture can ultimately be seen as outcomes of these interactions, making it essential to recognize the profound complexity and multi-dimensional nature of the globalization process in its impacts on agrarian activities.

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