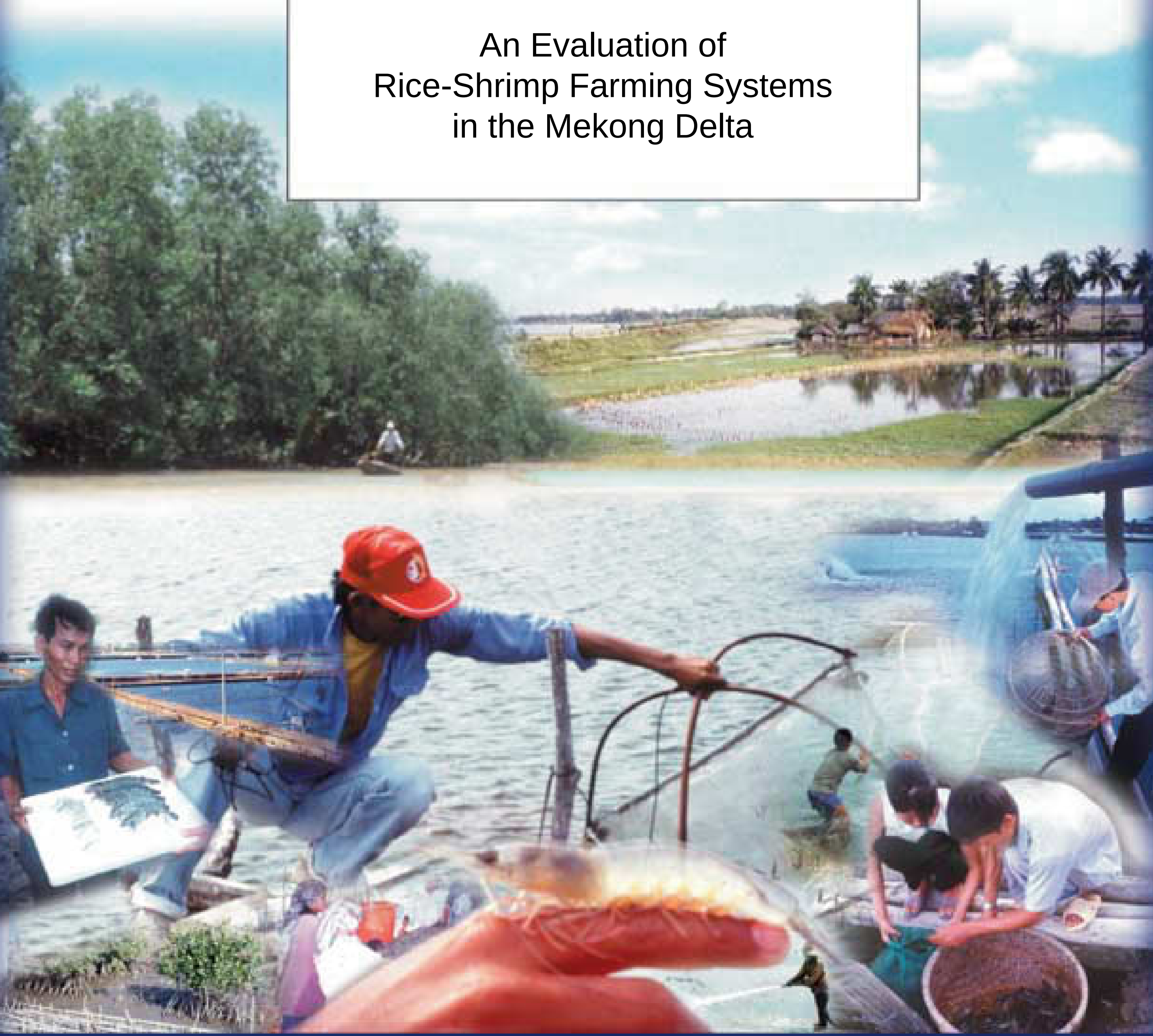
Shrimp Farming and the Environment

An Evaluation of Rice-Shrimp Farming Systems in the Mekong Delta



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AN EVALUATION OF RICE-SHRIMP FARMING SYSTEMS IN THE MEKONG DELTA

Donna Brennan
Faculty of Agriculture
University of Sydney, Australia.

Nigel Preston
CSIRO Marine Research
Cleveland, Australia.

and

Helena Clayton and Tran Thanh Be
Faculty of Agriculture
University of Sydney, Australia.

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Preparation of this document

The research reported in this paper was prepared under the World Bank/NACA/WWF/FAO Consortium Program on Shrimp Farming and the Environment. Due to the strong interest globally in shrimp farming and issues that have arisen from its development, the consortium program was initiated to analyze and share experiences on the better management of shrimp aquaculture in coastal areas. It is based on the recommendations of the FAO Bangkok Technical Consultation on Policies for Sustainable Shrimp Culture[1], a World Bank review on Shrimp Farming and the Environment[2], and an April 1999 meeting on shrimp management practices hosted by NACA and WWF in Bangkok, Thailand. The objectives of the consortium program are: (a) Generate a better understanding of key issues involved in sustainable shrimp aquaculture; (b) Encourage a debate and discussion around these issues that leads to consensus among stakeholders regarding key issues; (c) Identify better management strategies for sustainable shrimp aquaculture; (d) Evaluate the cost for adoption of such strategies as well as other potential barriers to their adoption; (e) Create a framework to review and evaluate successes and failures in sustainable shrimp aquaculture which can inform policy debate on management strategies for sustainable shrimp aquaculture; and (f) Identify future development activities and assistance required for the implementation of better management strategies that would support the development of a more sustainable shrimp culture industry. This paper represents one of the case studies from the Consortium Program.

The program was initiated in August 1999 and comprises complementary case studies on different aspects of shrimp aquaculture. The case studies provide wide geographical coverage of major shrimp producing countries in Asia and Latin America, as well as Africa, and studies and reviews of a global nature. The subject matter is broad, from farm level management practice, poverty issues, integration of shrimp aquaculture into coastal area management, shrimp health management and policy and legal issues. The case studies together provide an unique and important insight into the global status of shrimp aquaculture and management practices. The reports from the Consortium Program are available as web versions (http://www.enaca.org/shrimp) or in a limited number of hard copies.

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Correspondence: Donna Brennan, E-mail: donnabrennan@ozemail.com.au

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[1] FAO. 1998. Report of the Bangkok FAO Technical Consultation on Policies for Sustainable Shrimp Culture. Bangkok, Thailand, 8-11 December 1997. FAO Fisheries Report No. 572. Rome. 31 p.

[2] World Bank. 1998. Report on Shrimp Farming and the Environment – Can Shrimp Farming be Undertaken Sustainability? A Discussion Paper designed to assist in the development of Sustainable Shrimp Aquaculture. World Bank (Available on www.enaca.org/shrimp).

Abstract

In the coastal areas of the Mekong Delta, many farmers have adopted the practice of rice-shrimp farming. The rice-shrimp cultivation area in the Mekong Delta in 2000 was around 40,000 ha with an estimated shrimp production of 10,000 MT and rice production of 100,000 MT. The areas used for rice-shrimp farming have traditionally been used for wet season agricultural crops, and do not impinge on mangroves. The shrimp farmed in this system are stocked at low densities and feed inputs to the ponds are low. The freshwater rice crop provides a buffer between the brackish water shrimp crops. The inundation of saline water during the dry season does not appear to lead to a long-term build up of salts in the soil, thus rice yield performance is not compromised in the rice-shrimp system. These characteristics of the rice-shrimp system avoid many of the negative impacts that can results from intensive shrimp farming. Thus, in common with other extensive systems, the rice-shrimp system appears to one of the more ecologically sustainable approaches to shrimp farming.

The integration of dry season shrimp farming into rice fields has raised incomes over several consecutive seasons for many farmers in the region. However, our survey and studies of the rice-shrimp system has revealed some key constraints that need to be addressed in order improve environmental and economic sustainability. The results of our study show that the traditional practice of recruiting native shrimp species through water exchange is not sustainable because of the attendant build-up of sedimentation on the farm. The more recently adopted system of stocking with hatchery-reared postlarvae, combined with low water exchange, is promising but limited by the availability of healthy postlarvae and episodic outbreaks of disease. However, even with currently poor survival rates, many farmers are managing their financial risks well because of the diversified nature of the rice-shrimp farming system.

The current lack of investment in technology for improved health screening and domesticated seedstock production techniques are critical constraints to the sustainability of the rice-shrimp system. We advocate that a potentially achievable environmental goal would be to develop and implement closed shrimp production system supplied with domesticated, high-health seedstock. This would significantly improve the prospects of securing a more economically sustainable future for rice-shrimp farmers in the Mekong Delta.

Content

Abbreviations and Acronyms

C°	Celsius degrees
FAO	Food and Agriculture Organization of the United Nations
Ha	Hectare
Kg	Kilogram
M	Meter
MT	Metric Tons
NACA	Network of Aquaculture Centres in Asia-Pacific
ppt	Parts Per Thousand
VND	Vietnamese Dong (1 US$ = 14,000 VND in 1999)
WB	World Bank
WWF	World Wildlife Fund

Introduction

Integrated rice-shrimp farming is a system of alternative cropping of wet season rice and dry season shrimp on the same field. The system is widely practiced throughout the saline affected areas of the coastal provinces in the Mekong Delta (Figure 1).

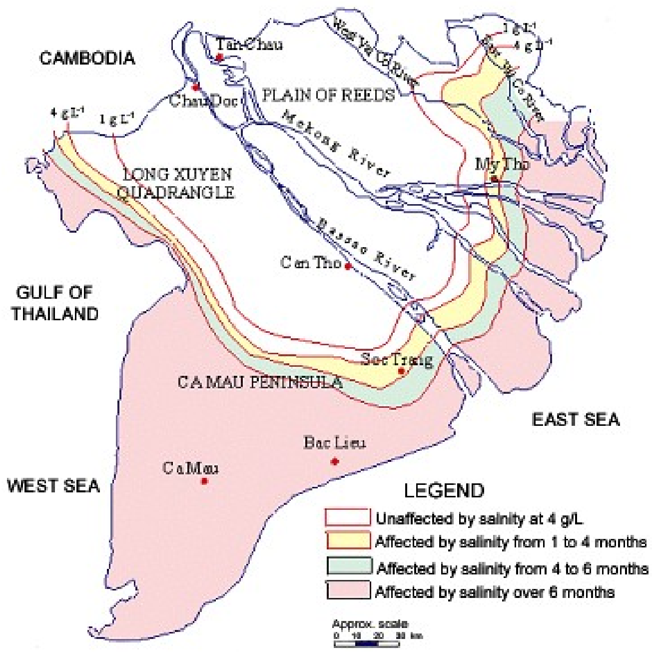

Figure 1. Map of saline intrusion in the coastal region of the Mekong Delta.

In the rice-shrimp system, the traditional rice fields have been redesigned with a trench and dike around the periphery of the field (Figure 2). The trench reduces the available area for rice production, but provides a refuge for shrimp away from the more extreme environmental conditions of the flooded rice field (Minh et al. 2002). A flapgate is used to manage tidal influx of water. At the start of the shrimp season, when the water in the local canal system has become saline[3], the trenches are filled and the entire field is flooded with saline water. At the beginning of the wet season, rainfalls as well as fresh water from the river are used to flush the fields of residual salinity, before planting the new rice crop.

[3] Typically, salinity levels at the beginning of the shrimp season are around 10ppt (January), rising to 25ppt in the peak of the dry season in April-May

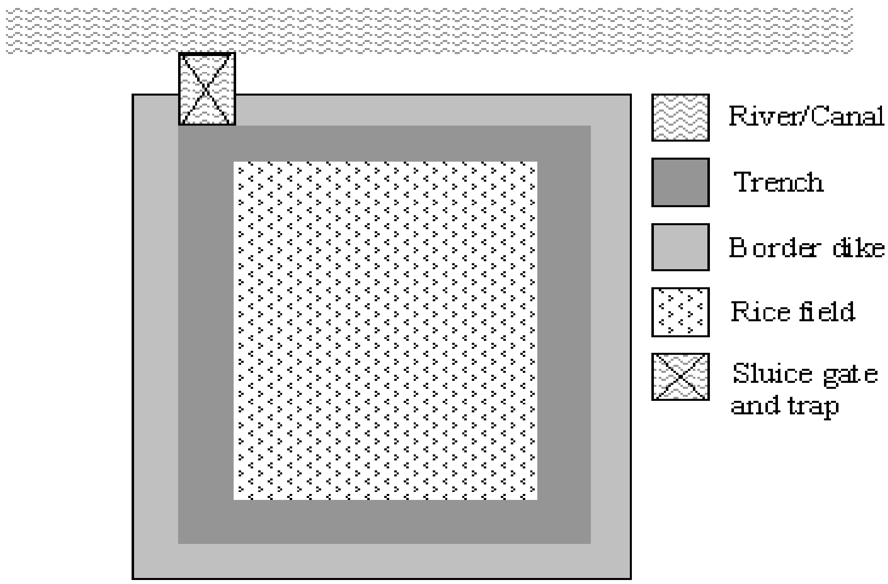

Figure 2. Schematic layout of the rice-shrimp farming system.

During the shrimp season some farmers rely on retaining the natural postlarvae or juveniles of several species including *Penaeus merguiensis*, *P. indicus* and *M. ensis* that enter the ponds during high tides. Others stock with *P. monodon*, a species that is not locally abundant, at stocking rates of 1-2 individuals per m^2. Some farmers add feed and chemical inputs to the pond. A recent survey of rice-shrimp farming practices showed that around 46% of shrimp farmers were using supplementary feeding, and for 80% of these the diets contained some manufactured feeds (Brennan et al. 1999; Brennan et al. 2000)[4]. The survey revealed a wide variety of practices among rice-shrimp farmers. However, we have restricted our evaluation in this discussion to two of the most common systems, one based on stocking with *P. monodon* postlarvae purchased from hatcheries the other based solely on native species commonly referred to as "natural shrimp" (*P. merguiensis*, *P. indicus* and *M.ensis*) where recruitment is achieved by frequent tidal water exchange.

We compared the economic and production characteristics of the *P. monodon* and natural shrimp systems using the information from a 1997 survey of 400 households in two rice-shrimp districts, My Xuyen and Gia Rai (Brennan et al. 1999, Brennan et al. 2000). The results showed that in the My Xuyen district, where soil conditions are generally more favorable, farmers practicing rice-shrimp farming earned substantial cash income from the rice crop (Table 1). In Gia Rai, farmers made little cash income from rice, due to lower yields. They did, however, generally sell enough rice to cover the costs of rice production, after retaining their household consumption requirements. Shrimp production was the most important single crop, in both *P. monodon* and natural shrimp farms. In the case of the *P. monodon* farms, the percentage contribution of shrimp to total household income was higher, as was the total income level. This reflects the much higher revenue earned from the sale of *P. monodon* compared to natural shrimp. Average stocking rates of *P.monodon* in these systems were 1.8 m^{-2} in My Xuyen and 1 m^{-2} in Gia Ria. The yields of *P. monodon* in the 1997 season were 152 kg ha^{-1} in My Xuyen and 29 kg ha^{-1} in Gia Rai. Poor yields of *P. monodon* in Gia Rai were partly compensated by relatively higher prices there (due to larger harvest size), lower costs, and high natural shrimp yields (75 kg ha^{-1} vs. 220 kg ha^{-1}). Other important sources of cash income were upland wet season crops (such as vegetables and coconuts) and off farm employment. In Gia Rai, significant income was earned from crab culture in the 1997 season.

[4] Shrimp feeds are manufactured in central Vietnam, although many farmers in the Delta buy feed imported from Thailand.

A characteristic of the rice-shrimp farming system is the generally high level of income diversification at the household level. This diversification of income means that farm households have alternative sources of income in the event of high shrimp mortality. Moreover, the farming system allows for the production of rice and other staple items for household consumption, further insuring against the risks associated with shrimp production.

Table 1. The average performance of farm households practicing rice-shrimp farming in two districts of the Mekong Delta. The results are based on a survey of 200 households in the My Xuyen district and 173 households in the Gai Rai district.

Shrimp Stocking Density and Yield	***P. monodon***		**Natural shrimp**	
Stocking density (*P. monodon* m^{-2})	1.9	1	*0	*0
P. monodon yield kg ha^{-1}	125	30	0	0
Natural shrimp yield kg ha^{-1}	75	219	150	257
Contribution to household cash income (percent)	My Xuyen	Gia Rai	My Xuyen	Gia Rai
Rice	16	0	17	6
Shrimp	60	65	40	55
Other Aquaculture	2	13	7	19
Upland crops	5	3	8	8
Off farm income	17	18	28	11
Value of subsistence	243	107	120	155
Household Cash Income US$	983	1041	480	767
Total Household Income US$	1,226	1,147	601	922

*Recruitment levels of natural shrimp were not measured.

Sustainability Issues

Salinity

Saline intrusion is a naturally occurring phenomenon that affects land productivity even in the absence of shrimp culture. In general the saline intrusion problem means there is only sufficient time to grow one rice crop per year. However, in the districts closest to the coast, early saline intrusion (an early dry season) can also mean that the wet season crop is affected towards the end of the growing season, because canal water is too saline for irrigation. The practice of shrimp culture exacerbates the limited cropping cycle because farmers delay planting in order to wait for rains to flush the salts from the soil after the shrimp phase. This increases the risk that the canal water will be salty before the rice crop has been harvested.

There is scant evidence on the effects of soil salinisation from shrimp culture on subsequent rice yields. While Tran et al. (1999) concluded that salt leaching into neighboring rice fields caused significant damage to rice fields, comparisons between rice yields in rice-shrimp and rice monoculture fields can be confounded by spatial factors affecting the choice of farming system. In a study of soil-water dynamics in rice monoculture and rice-shrimp fields, Phong et al. (2002) observed that soil salinity was generally lower in rice-shrimp fields than in rice monoculture fields. They explained this observation in terms of the relative position of rice monoculture and rice shrimp fields in the system. Rice-shrimp fields are generally located nearby to canals and are engineered to allow effective water exchange. Farmers can take advantage of this to leach the salts from the system at the beginning of the rainy season. In contrast, the salinity that builds up in some rice monoculture fields due to capillary rise during the dry season could not be flushed away in areas that did not have good access to canal water. Phong et al. (2002) also concluded that the heavy rains that occurred at the beginning of the wet season were effective in leaching salts in the rice-shrimp fields, and suggested that there was no long term build up in salts from the practice. They did however make recommendations about appropriate timing of rice planting for such systems, to ensure that the crop was not planted too early.

De et al. (2002) report on the promising performance of new rice varieties that are short duration (115-120 day) and relatively salt tolerant. They recommended the use of MTL119, which performed better in the field trials they conducted, compared to the most commonly used variety. They also noted that yields were relatively higher in the rice monoculture system, compared to rice shrimp, which provides contrasting evidence to conclusions of Phong et al. (2002) about salt leaching. A possible explanation for this is the wide spatial variation in soil salinity, as reported by Phong et al. (2002).

The rapid changes in pond salinity that occur during the transition between wet and dry seasons (Figure 3) have implications for risk management of the brackish water shrimp crops. The precise physiological tolerances to variations in salinity levels are not well understood for the species of shrimp farmed in the rice-shrimp system. In common with other *Penaeus* species, *P. monodon, P. merguiensis* and *P. indicus* are euryhaline species capable of actively osmoregulating their body fluids when exposed to a wide range of external salinities (Dall et al. 1990). However, studies of osmoregulatory ability indicate that *P. monodon* has a limited ability to survive in very low salinities (Ferraris et al. 1987). Field studies of the growth and survival of *P. monodon* in rice-shrimp ponds have recorded complete stock losses following rapid falls in pond salinity (Minh et al. 2002). However, field observations also indicated that the *P. monodon* were infected with white spot syndrome virus, as was subsequently confirmed by PCR analysis. Whilst the precise cause of the shrimp deaths could not be determined these observations are consistent with previous observations that rapid changes in pond salinity increase the risk of mass-mortalities in shrimp ponds (Chanratchakool et al.1998).

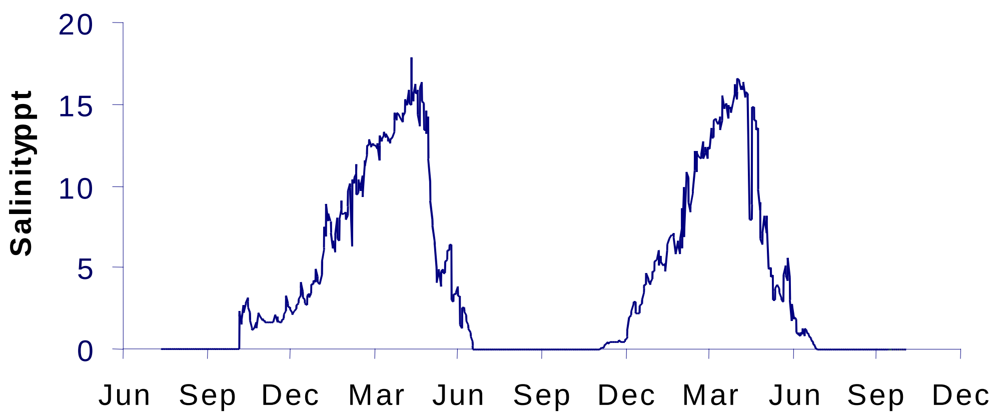

Figure 3. Seasonal variation in salinity of the rice-shrimp canal

Shrimp Pond Conditions

Rice-shrimp ponds typically have a very shallow central platform (≈20 cm deep) where the rice is grown in the wet season. The central platform occupies about 80% of the total pond area and is surrounded by a trench (≈ 1 m deep). Studies of the physical conditions in rice-shrimp ponds have shown pronounced diurnal variation in pond temperatures, dissolved oxygen and pH (Minh et al. 2002). Conditions on the platform and surface of the trench are more extreme than at the bottom of the trench. For example, the temperature at the bottom of the trench averaged 1.6 °C cooler than at the surface (Minh et al. 2002). Assuming the shrimp were able to avoid the platform extremes, the physical conditions in the trench of rice-shrimp ponds were within acceptable tolerance limits for *P. monodon*. This is reflected in the growth, survival and yields of *P. monodon* grown at rice-shrimp study sites that were prepared and operated according to current best management practices for the rice-shrimp system (Minh et al. 2002a) and monitored throughout the shrimp grow-out season (Minh et al. 2002a). The growth rates (25.64 ± 0.2 g in 110 days), survival (88 ± 3%) and pond yields (362 ± 39 kg/ha) are indicative of what can be achieved in well-managed rice-shrimp ponds. These growth rates are comparable to those obtained at equivalent temperatures in intensively managed shrimp ponds (Jackson and Wang 1998). However, recent viral screening of *P. monodon* postlarvae from hatcheries in the Mekong Delta indicated that the prevalence of infection with yellow head complex viruses was in excess of 50% (Walker et al. 2002). High levels of viral pathogens in hatcheries and farm stocks pose a critical threat to the sustainable production of the shrimp in the rice-shrimp system and all other shrimp production systems in the Mekong Delta.

Sedimentation

The inundation and exchange of turbid river water in the dry season leads to a build up of sediment in the rice fields, which must be removed to allow for effective water management for the rice crop. The removal of sediment is a labor intensive process that must be completed in a short period of time (between rice harvest and before stocking). Thus the removal of sediment imposes a large annual cash cost upon the farm, as it is usually necessary to employ casual labor to complete this task.

The disposal of the large amounts of sediment removed annually from the shrimp trenches is a serious problem. Some farms dump the sediment back in the river, although in some regions this practice is illegal. In the majority of cases, accessibility to main canals and the cost of transport mean that there are no alternatives for removing the sediment from the farm (Tran 1994). Disposal of sediment within the farm boundary can be achieved in several ways. Some farmers are able to dispose of the sediment by spreading it around the house or vegetable plots, and other farmers pile the sediment onto the dikes of the polder. There is a limit to the amount of sediment that can be disposed in these ways, which inevitably leads to the construction of additional dikes within the rice field, solely for the purposes of sediment disposal. The build up of additional dike area removes the area of land available for rice production with implications for the long-term productivity of the farm.

The total sediment load depends upon the volume of water brought into the polder during the season. The canal water in the vicinity of rice-shrimp farms is highly turbid with levels of total suspended solids typically in the range of 50 mg l^{-1} to 250 mg l^{-1}[5]. In areas where natural recruitment systems, based on daily water exchange, have been practiced for more than a decade, there is evidence of severe land loss on some farms due to the deposition of sediment. For example, the area of a rice shrimp polder that is taken up by dikes at the time of polder construction is typically around 10%. In the district of Gia Rai where rice-shrimp farming has been practiced for more than 10 years, the average farm area taken up by dikes is around 24%. Twenty percent of farms have more than 30% of their polders taken up by dikes (Brennan et al. 1999).

Clayton (2002a) estimated the long-term economic trade offs associated with high water exchange rates using a bioeconomic simulation model. High water exchange rates increase the chance of capturing wild-sourced postlarvae, bringing short-term economic benefit. In the longer term, the loss of land associated with high sedimentation rates leads to reduced farm productivity and lower income. However, Clayton (2002a) concluded that, for rice-shrimp farmers that rely on natural recruitment, there was little incentive for farmers to lower water exchange rates in order to maintain an economic benefit from the land over the longer term. This was because the main source of income for the farming system was a degrading one and under non-zero discount rates it was optimal to “mine” the land now rather than preserve it for rice cropping in the future. This result was driven by the relatively high income from natural shrimp relative to rice farming and was robust to a range of discount factors and planning horizons, although the relative

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[5] The density of total suspended solids in the water column was measured using a data-logger positioned at the site of an experimental farm in My Xuyen in 1998

benefits of the "degrading" system are more pronounced at high discount rates and short planning horizons. Since the circumstances of rice-shrimp farmers imply high discount rates (they are poor and have little access to credit) and short planning horizons (due to insecure tenure) farmers will have little incentive to stop degrading the land if they only have natural shrimp or rice farming as the available land use alternatives.

In contrast to the natural shrimp system, we advocate that a system based on artificially stocked *P. monodon* is less damaging to long-term farm productivity for a number of reasons. First, the link between recruitment of shrimp and water exchange is significantly reduced. While farmers could continue to practice high water exchange in order to recruit additional "free" native postlarvae, there is a large opportunity cost associated with degrading land because returns per unit area are much higher under *P. monodon* farming. While the poor performance of *P. monodon* farming in Gia Rai has so far not provided farmers with an incentive for abandoning natural shrimp recruitment, Clayton (2002b) demonstrates how the introduction of better performing monodon systems could reverse the incentive toward environmental preservation, even under short planning horizons and high discount rates. Second, there is some preliminary evidence that low water exchange systems provide a more stable pond environment and reduce the risk of shrimp mortality (Hoa et al. 2002). These factors imply that the best practice for rice-shrimp farming is to adopt low water exchange monodon systems, in order to achieve higher income that can be sustained over the longer term without causing on-farm land degradation.

Seedstock (postlarvae) Supply Issues

Surveys of *P. monodon* seedstock (postlarvae) supplies have revealed extreme shortages throughout the Mekong Delta shrimp farming regions (Hai et al. 2002). Most of the *P. monodon* postlarvae used to stock shrimp farms in the Mekong Delta have to be transported for several hours by road from hatcheries in central Vietnam (Hai et al. 2002). Furthermore, efforts to acclimatize the postlarvae to the low salinity conditions of the rice-shrimp ponds are highly variable and are often unsuccessful (Hai et al. 2002). The high levels of viral infection in postlarvae (Walker et al. 2002) further exacerbate the mortalities due to physical stresses.

Farmers pay very high prices for seedstock and if losses occur they can have serious financial problems, especially if they have borrowed money to finance their operation. For example, the cost of stocking a shrimp pond in My Xuyen in 1997[6] was 3.6 million VND; which is 3 times the net cash income earned from the rice crop. This implies that financial sustainability is a major concern for rice-shrimp farms.

Financial Sustainability

One of the characteristics of shrimp farming is the high risk of mortality through disease. Throughout Asia, "boom and bust" cycles have been observed at the industry level. At the farm level, the operator faces large risk because of the high cash costs of seedstock and feed, and the risk of poor survival. In the Mekong Delta, very poor survival rates have been observed. For example, in a three-year record keeping study in two provinces, Tran and Hiep (2000) report average survival rates of 15- 20% in one location, and 1-5% in another. Brennan et al. (1999) report on a wide variation in survival rate across 400 farms in the 1997 season. Some farmers achieved as high as 70 percent survival, 14 percent experienced mass mortality.

While good survival is critical to the success of shrimp farming, Brennan et al (1999) point out that the relatively low input costs of the rice shrimp system mean that survival does not have to be very high to

[6] Based on mean stocking rate of 1.8 postlarvae per m^2 and a price of 200 VND per post larvae (Brennan et al. 1999).

break even. For example, survival rates only need to be 8% to recover seedstock costs if no feeding is used; and 17% to cover the typical costs of stocking with higher quality seed and typical feed costs observed on farms. Many farmers (50 %) in their survey made very large profits (in excess of 10 million dong) through good survival, while many others (16%) failed to achieve the break-even survival rate and lost significant cash from shrimp farming.

The shrimp farming component of the rice-shrimp system is clearly a very risky enterprise. There are two better management strategies that can be employed to reduce the impacts of risky cash income. First, income diversification can provide a means of spreading risk, or proving"insurance" for family consumption needs. The rice and other cropping activities observed in the rice-shrimp farming system (and the significant level of off-farm income) provides the farm with subsistence needs as well as other sources of cash for the household. This diversification of farm income explains why, despite variable performance in survival, farmers practicing the rice-shrimp farming system have, in general, managed to achieve financial sustainability.

A second strategy for managing risky income from shrimp is to save (or invest) in years of good production, to provide a source of cash in years of shrimp crop failure. The use of savings, either in terms of cash, gold or household assets was an observed strategy against risk on shrimp farms in the Mekong Delta (Brennan 2002). This practice could be encouraged more widely through extension, and improved financial institutions that provided a good return to savings.

Adoption and Incentive Issues

Comparisons between the financial and environmental performance of two types of shrimp farms (*P. monodon* and natural shrimp) reveal that the *P. monodon* systems are more sustainable. However, our experience with farmers in Gia Rai district is that they prefer to practice a combination of natural recruitment and *P. monodon* farming. This is because, in the context of observed poor survival of *P. monodon*, they see high water exchange as a means of boosting their income via free recruitment of natural seedstock. While preliminary results indicate that the pond environment and *P. monodon* yield could improve if farmers practiced low water exchange, leading to higher sustained income over the longer term, the demonstration of this to farmers is a major challenge. The key to convincing farmers of the benefits of the more sustainable low-exchange system is to change their perceptions about the yield risks and returns associated with it. However, at present there are external factors, particularly the critical lack of seedstock and the prevalence of viral disease, that affect the survival of shrimp even in the presence of good, low water exchange, pond management practices. Until there is some control over seedstock quantity and quality, the returns from lower exchange, non-degrading farm management practices will be more difficult to demonstrate, and it is likely that farmers will continue to practice the mixed natural shrimp/monodon stocking strategy that gives them a more certain short-term income.

Conclusions

The development of the rice-shrimp farming system in the Mekong Delta has been very rapid due to the high returns from shrimp production in the seasonally brackish rice growing regions. The most serious environmental issue is the sedimentation of ponds associated with “natural shrimp farming” resulting in the loss of both shrimp and rice land. Although environmentally unsustainable, this practice has been driven by a rational response by farmers to economic incentives – the land has little value in rice production compared to the high returns from shrimp production. The more ecologically sustainable development solution, which farmers themselves are now beginning to adopt, is to switch to hatchery reared *P. monodon* seedstock for stocking ponds. However, there are two major constraints to the widespread adoption of *P. monodon* as an alternative to the degrading natural shrimp practice. These are shortages in the supply of postlarvae, and the high incidence viral disease in the seed stock. There is an equally urgent need to improve the quantity and quality of locally available seedstock for stocking shrimp farms in the Mekong Delta. We advocate that it is essential to address these issues in parallel. Focusing on disease alone would not alleviate the critical shortages in seedstock. Conversely, introducing improved seedstock production technology without the capacity for viral health screening could further exacerbate the current problems.

One of the major factors contributing to the problems in the quality and quantity of shrimp seedstock in Viet Nam, and elsewhere, is the current reliance on wild broodstock. Reliance on wild broodstock is risky, inefficient and precludes the opportunity to enhance production through selective breeding and controlling the spread of disease. This problem is not unique to Viet Nam; only a small percentage (probably < 5%) of global shrimp farm production is currently produced from domesticated stocks.

We also suggest that progressing from "open" systems with frequent water exchange to low water exchange practices could enhance the ecological and economic sustainability of the shrimp component of the rice-shrimp system. However, low water exchange will remain a high-risk strategy until improved seedstock supply and reduced risks of viral infections can reduce the cost of stocking.

Financial sustainability is a key concern with many farmers getting into debt when crop losses occur, which also raises social issues of landlessness and severe economic hardship. However, financial sustainability is a common issue in all types of shrimp farming systems where cash investments are made and there is a risk of total crop failure. Improvements in the very poor survival rates of *P. monodon* in the Mekong Delta, through improved hatchery and disease screening technology should assist in reducing the financial risks of the system.

Moreover, the rice-shrimp farming system provides relatively better financial security than alternative extensive monoculture systems. A characteristic of the rice-shrimp farming system, is that the wet season agricultural activities provide food security for the farm household, and the low labor intensity of the farming practice means that family members can work off farm, further adding to household income security.

An emerging sustainability issue is the trend towards intensification. As farmers are becoming more experienced with shrimp farming they have tended to intensify their practices, and some are abandoning the rice crop cycle and transforming their rice-shrimp polders into conventional shrimp ponds. Concern over the environmental implications and financial risks of more intensive monoculture systems has induced local policy makers to try to regulate land practices - in some areas, land has been zoned as suitable only for integrated rice-shrimp farms.

References

Brennan, D., H. Clayton, T.T. Be and T. T. N. Hiep. 1999. *Economic and social characteristics and farm management practices of farms in the brackish water region of Soc Trang and Bac Lieu provinces, Mekong Delta, Vietnam: Results of a 1997 survey*. http://www.reap.com.au/riceshrimpsurvey97.pdf

Brennan, D.C., H. Clayton and T.B. Tran. 2000. Economic characteristics of rice shrimp farms in the Mekong Delta, Vietnam. *Journal of Aquaculture Economics and Management* Vol. 4 (3-4):127-130.

Brennan, D. 2002. Farmer risk aversion, savings and technology choice. *Australian Journal of Agricultural Economics* (In press).

Clayton, H. 2002a. Bioeconomic factors of sedimentation and land loss in the natural rice-shrimp system. *Sustainability of the rice-shrimp systems in the Mekong Delta, Vietnam, ACIAR Technical Report* (In press).

Clayton, H. 2002b. *The Economics of Land Degradation in the Rice-shrimp System in the Mekong Delta, Vietnam* Unpublished Masters of Agricultural Economics Thesis, Department of Agricultural Economics, University of Sydney.

Chanratchakool, P., J.F. Turnbull, S.J. Funge-Smith, I.H.MacRae and C. Limsuwan. 1998. *Health Management in Shrimp Ponds*. Bangkok, Aquatic Animal Health Research Institute, Department of Fisheries, Kasetsart University, 152 p.

De, N.N., L.X. Thai and P.T. Phan. 2002. Selection of suitable rice varieties for monoculture and rice-shrimp farming systems in the Mekong Delta of Vietnam. *Sustainability of the rice-shrimp systems in the Mekong Delta, Vietnam, ACIAR Technical Report* (In press)

Dall, W., B.J. Hill, P.C. Rothlisberg and D.J. Staples.1990. The biology of the Penaeidea. *Advances in Marine Biology Vol 27.*

Ferraris, R.P., F.D. Parado-Estepa, E.G. De Jesus and J.M. Ladja. 1987. Osmotic and chloride regulation in the haemolymph of the tiger prawn Penaeus monodon during moulting in various salinities. *Marine Biology 95:*377-385

Hai, T.N., N.P. Preston and D. Brennan. 2002. Shrimp hatchery production in the coastal provinces of the Mekong Delta *Sustainability of the rice-shrimp systems in the Mekong Delta, Vietnam, ACIAR Technical Report* (In press).

Hoa, T.T.T., C. Jackson, L.B. Ngoc, T.V. Phuong, T.H. Minh, N.T. Phuong and N. Preston. 2002. The effects of water exchange on water quality, sedimentation rates, and productivity and growth of *Penaeus monodon* in a low-intensity integrated rice-shrimp system. *Sustainability of the rice-shrimp systems in the Mekong Delta, Vietnam, ACIAR Technical Report* (In press)

Jackson, C. and L. Wang. 1998. Modeling growth rate of *Penaeus monodon*, in intensively managed ponds: effects of temperature, pond age and stocking density. *Aquaculture Research 29(1):*27-36.

Minh, T.H., N.T. Phuong, N. Preston, C. Jackson and P. Walker. 2002b. Best management practices for *P.monodon* production in rice-shrimp systems in the Mekong Delta. *Series 1-6 (Electronic CD-ROM publication), Aquaculture Sciences Institute*, Can Tho University, Vietnam.

Minh, T.H., C.J. Jackson, T.T.T Hoa, L.B. Ngoc and N. Preston. 2002 Growth and survival of *Penaeus monodon* in relation to the physical conditions in rice-shrimp ponds in the Mekong Delta. *Sustainability of rice-shrimp systems in the Mekong Delta, Vietnam, ACIAR Technical Report* (In press).

Phong, N.D., T.V. My, N.D. Nang, T.P. Tuong, T.N. Phuoc and N.H. Trung. 2002. Salinity dynamics and its implications for cropping patterns and rice performance in rice-shrimp farming systems in My Xuyen and Gia Rai. *Sustainability of rice-shrimp systems in the Mekong Delta, Vietnam, ACIAR Technical Report* (In press).

Tran, T.B. 1994. *Sustainability of Rice-Shrimp Farming Systems in a Brackish Water Area in the Mekong Delta of Vietnam*, Master of Science Thesis, University of Western Sydney, Hawkesbury, Australia, 199 p.

Tran, T.B., L.C. Dung and D.C. Brennan. 1999. Environmental costs of shrimp culture in the rice growing regions of the Mekong Delta. *Aquaculture Economics and Management Vol 3 (1):*31-43.

Tran, T.B. and T.T.N. Hiep. 2000. *Rice-shrimp Farming Systems in the Study Area: Changes over Three Years, 1997-99*, ACIAR Rice-Shrimp Final Workshop, December 12-15, Can Tho University, Vietnam.

Walker, P.J., T. Phan, R.A.J. Hodgson, J.A. Cowley, T.W. Flegel, V. Boonsaeng and B.Withychmnarkul. 2002. Yellow head-complex viruses occur commonly in healthy *P. monodon* in Asia and Australia. *World Aquaculture Society Book of Abstracts. April 2002*, Beijing, China p: 773.

The World Bank - Netherlands Partnership Program

The World Bank
1818 H Street, NW
Washington D.C. 20433-1234, USA
Telephone : 202-477-1234
Facsimile : 202-477-6391
Telex : MCI 64145 WORLDBANK
MCI 248423 WORLDBANK
Web page : www.worldbank.org
E-mail : rzweig@worldbank.org

Network of Aquaculture Centres in Asia-Pacific (NACA)

Department of Fisheries
Kasetsart University Campus
Ladyao, Jatujak,
Bangkok 10900, Thailand
Web page : www.enaca.org
E-mail : shrimp@enaca.org

World Wildlife Fund (WWF)

1250 24th Street, NW
Washington D.C. 20037, USA
Web page : www.worldwildlife.org
E-mail : shrimp.aquaculture@wwfus.org

Food and Agriculture Organization of the United Nations (FAO)

Viale delle Terme di Carracalla
Rome 00100, Italy
Web page : www.fao.org
E-mail : FI-Inquiries@fao.org

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