Ind. Jn. of Agri. Econ.
Vol. 61, No. 1, Jan.-March 2006

RESEARCH NOTES

A Logistic Regression of Risk Factors for Disease Occurrence on Coastal Andhra Shrimp Farms

K. Uma Devi and Y. Eswara Prasad*

I

INTRODUCTION

Prawn or shrimp farming[1] is one of the sustainable activities/enterprise having a stake in the coastal zone. India is one of the largest producers of shrimp and in the past few decades, has become a leading player both in the inland and brackish water aquaculture production. Shrimp culture in its traditional form has been in practice in the country since time immemorial. Commercial shrimp farming started gaining roots only during the mid-eighties and peaked in the nineties.

Marine Products Exports Development Authority (MPEDA) estimated an area of about 0.194 million ha under culture producing about 1,27,170 MT of shrimp during the year. Shrimp aquaculture has been in practice in all the coastal districts of Andhra Pradesh. The state ranks first in coastal aquaculture production. Frozen shrimp is the leading commodity among exports of cultured shrimp from Andhra Pradesh.

Diseases represent the biggest obstacle to the future of shrimp farming. High profits from shrimp farming and increasing coastal land prices pushed shrimp farmers towards more intensive operation. The conditions associated with intensification included: increased farm densities in shrimp-culture areas, greatly increased feed and other inputs per unit of pond area, increased effluent wasteloads and increased disease occurrences from various causes.

The risk of disease seems to increase with intensity of farming and thus the density of shrimp in the pond. Disease occurrence in shrimp ponds in Hainan, China was closely associated with excessive stockpile and poor water quality (Spaargaren, 1998). There appears to be a clear linkage between environmental conditions and disease outbreak. For example, low oxygen levels, which is a common problem in ponds with high stocking density, increases sensitivity to vibriosis in penaeid shrimp (Le Moullac *et al.,*1998). Lundin (1995) stressed that a drastic change in the practices was needed, particularly on the management side to make shrimp farming a sustainable activity. Balaji (1999) studied the major outbreak of shrimp disease

*Ph.D. Student and Professor and Head, respectively, Department of Agricultural Economics, College of Agriculture, Rajendranagar, Hyderabad - 500 030.

resulting in panic harvest in Nellore district of Andhra Pradesh. Frequent disease outbreaks often resulted in widespread crop failures. The crop loss due to disease in brackish water area developed for shrimp farming during the first and second crops for the year 2001-02 in Andhra Pradesh were 7,766 MT and 6,084 MT respectively.

An interesting finding of Pe and Smith (1999) using logistic regression and multiple analysis methods provided strong evidence that environmental problem is the cause of reduced productivity and incidence of disease in shrimp farms. Leung and Tran (2000) developed a probabilistic neural network (PNN) to predict shrimp disease outbreaks in Vietnam using farm-level data from 480 Vietnamese shrimp farms.

The MPEDA/NACA (2003) study revealed that the dominant shrimp disease problem in Nellore and West Godavari districts was White Spot Disease (WSD). The risk factors at each stage of the cropping cycle and their relationship to WSD outbreaks are illustrated in a "web of disease causation" (see Figure 1).

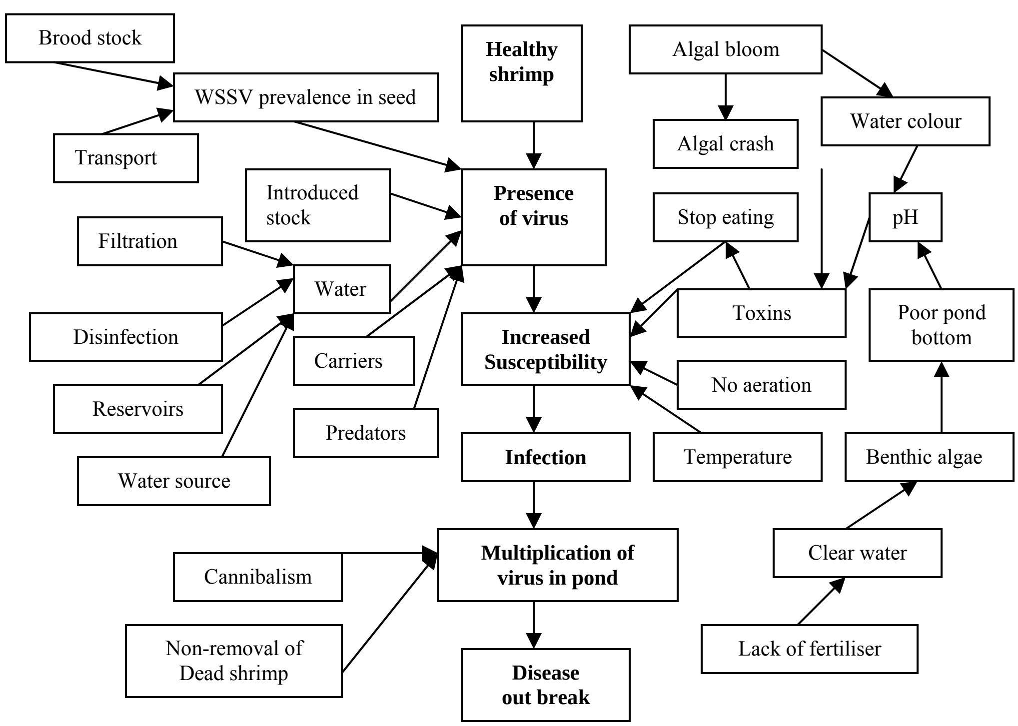

Figure 1. Web of White Spot Disease Causation

A solution to disease problems involves both prevention and cure. There are no medications to treat shrimp viruses, but management techniques have evolved which lessen their impact. Disease prevention focuses on the use of specific-pathogen free

(SPF) or specific-pathogen resistant (SPR) seed stock, seed stock pre-screened for specific pathogens, appropriate site selection and farm design, and application of sustainable farm-management practices (Leung *et al.*, 2000). Research and improved extension activities are needed to properly identify shrimp diseases, a necessary step leading to prevention and cure.

The boom period of commercial-scale shrimp culture in India started in 1990 and the bust came in 1995-96, with the outbreak of viral disease. This study was taken up with the major objective of identifying the factors responsible for disease occurrence in shrimp in the study area. Logistic regression models were evaluated from a set of 23 variables, including site characteristics, farming systems and farming practices. Logistic regression was performed separately for extensive and semi-intensive shrimp farms for the selected farmers in Coastal Andhra.

II

DATA AND METHODOLOGY

Costal Andhra was divided into low, medium and high concentrated groups based on the concentration of shrimp farms and one district was randomly selected from each group, i.e., Visakhapatnam, Nellore and West Godavari districts. Based on the maximum number of shrimp farmers, two mandals in each district were purposively selected. The farmers of each village were selected through proportionate random sampling method. Thirty farmers from each mandal were selected randomly making a total sample of 180 prawn farmers.

Four major types of shrimp farms are used in India, traditional, extensive, semi-intensive and intensive systems (Hein, 2000) based on the stocking density (shrimp/m^2) and management. The farming systems observed in the study area were extensive and semi-intensive methods. The selected farmers in each village were post-stratified into two groups, i.e., extensive[2] and semi-intensive[3] based on the system of cultivation. The data were collected through comprehensive pre-tested schedules and personal interviews during the year 2002-03 for the period 2001-02 by recall memory method.

Logistic Regression

Johnson-Iferulundu and Kaneene (1998) used logistic regression model to identify the management practices that posed risk factors for *M. Paratuberculosis* infection of dairy herds in Michigan. While disease prediction models are widely used to predict incidence of either pests or pathogens in the field for crop protection and disease of land animals, application of disease-prediction models in aquaculture is very rare.

Logistic regression or logit analysis is a popular statistical modeling technique in which the probability of a dichotomous outcome is related to a set of potential explanatory variables. A dichotomous outcome Y, (for example, Y=1 if disease loss $\geq$ 20 per cent of crop, Y=0 if <20 per cent has an expected value, E (Y), assumed to be P (P=the probability that the outcome occurs).

One can usually assume that P was related to a set of potential explanatory variables in the form:

$$Y=P+\varepsilon=\beta_0+\beta_1X_1+\beta_2X_2+\ldots\ldots\ldots..+\beta_{23}X_{23}+\varepsilon \qquad \ldots.(1)$$

Where [i]β_0 the intercept, $\beta_{1....}\beta_k$ are the coefficients associated with each explanatory variable $X_1\ldots.X_k$ and ε an error term. Regression Y on X's using ordinary least squares will lead to three problems. First, the error term, ε, obviously not normally distributed as was generally assumed, and more importantly, estimated probabilities can lie outside the range (0, 1). Furthermore, the error variance was not constant across levels of the X's. However, one can assume that P follows a logistic distribution.

$$P=1/(1+\exp[-(\beta_0+\beta_1X_1+\beta_2X_2+\ldots\ldots\ldots..+\beta_{23}X_{23})] \qquad \ldots.(2)$$

Rearranging terms, the equation 2 can be expressed as:

$$P/1\text{-}P=\exp[-(\beta_0+\beta_1X_1+\beta_2X_2+\ldots\ldots\ldots..+\beta_{23}X_{23})] \qquad \ldots.(3)$$

Where P/1-P is the 'odds' of the outcome such as the occurrence of the disease. It was clear from the equation 3 that the logarithm of the odds, or simply log odds, was a linear function of the explanatory variables, X's as:

$$\log[P/(1-P)]=\beta_0+\beta_1X_1+\beta_2X_2+\ldots\ldots\ldots..+\beta_kX_k \qquad \ldots.(4)$$

Since P was assumed to follow a logistic distribution, maximum-likelihood methods can be used to estimate the coefficients $\beta_{1....}\beta_{k.}$ Exp (β) represents the expected change in the odds of disease occurrence versus no disease per unit change in the explanatory variable, other things being equal. The logistic procedure in the SPSS package was used in the analysis for identifying the factors responsible for shrimp disease occurrence in Coastal Andhra.

III

RESULTS AND DISCUSSION

Logistic regression models were fitted for each level of shrimp culture intensity (using all 23 variables). Twenty-three variables including 10 continuous and 13 nominal variables describing the site, farming system and farming practice were used as potential factors in explaining disease occurrence. A list of 23 variables is shown in Appendix. The χ^2 values of the two models are statistically significant implying that the fitted models (containing the constant and the explanatory variables) fit the data quite well.

The estimated βs for the logistic regressions and their significance levels (p-values) are presented in Table 1. The estimated coefficients (βs) reflect the effects of the corresponding explanatory variables on the log odds of a disease occurrence. A negative coefficient indicates a positive (decreased) effect on disease occurrence (i.e., an increase in the level of that variable will reduce disease occurrence, *ceteris paribus*). Conversely, a positive coefficient suggests than an increase in the corresponding variable will increase disease occurrence (again given that all the other variables remain the same). Exp (β) represents the expected change in the odds of disease occurrence versus no disease per unit change in the explanatory variable, other things being equal.

TABLE 1. FITTED LOGISTIC-REGRESSION MODELS FOR SEMI-INTENSIVE AND EXTENSIVE SHRIMP FARMS

		Semi-intensive		Extensive	
Sr. No.	Variables	β	P	β	P
(1)	(2)	(3)	(4)	(5)	(6)
	Site characteristics				
1.	No. of years of shrimp farming at site	0.337	0.424	0.076	0.47
2.	Prior land use	-2.259	0.055	0.672	0.069
3.	Farm operator	-0.566	0.766	-1.489	0.016
4.	Farm area	0.670	0.057	0.031	0.077
5.	Source of water	-1.922	0.079	0.046	0.857
6.	Salinity of intake water	-0.951	0.635	0.815	0.324
7.	No. of farms within 3 kms	0.421	0.643	-0.162	0.328
8.	No. of farms share water supply	-0.623	0.48	-0.162	0.587
9.	No. of farms discharge effluent into water supply canal	0.313	0.051	2.731	0.035
10.	Measures taken to reduce environmental impacts	-1.006	0.142	-18.142	0.752
	Farming systems and practices				
11.	Stocking density	0.409	0.774	-0.729	0.072
12.	Dry pond	-3.071	0.300	0.455	0.546
13.	Silt removal	1.211	0.095	0.266	0.024
14.	Maintain or remove dykes	-1.951	0.373	0.369	0.612
15.	Aeration	28.139	0.492	0.626	0.38
16.	Apply chemical	-12.426	0.021	-0.134	0.862
17.	Apply fertilisers	1.194	0.172	0.315	0.261
18.	Frequency of water exchange	3.647	0.04	0.493	0.059
19.	Discharge	2.41	0.083	0.089	0.595
20.	Feed	3.738	0.082	-2.305	0.228
21.	No. of shrimp management/monitoring measures	-0.654	0.577	-0.885	0.121
22.	No. of water monitoring measures	0.847	0.216	-0.679	0.026
23.	No. of feed and cost measures	-1.328	0.37	-0.725	0.032
	Constant	-23.545	0.584	1.114	0.737
	Model χ^2	52.987	0.0001	58.653	0.012
	No. of observations	70		110	

Note: p-value represents the level of significance.

Site Characteristics

Odds of disease occurrence[4] increased with timeframe at a given site for both semi-intensive and extensive cultures (Table 2). Perhaps old, intensive farms were more susceptible to disease because they were built in areas where shrimp farms already existed. With the gain in experience the shrimp farmers in Coastal Andhra might be using high stocking densities, formulated diet and concentrating less on the sustainability shrimp farming. This may lead to serious shrimp-disease outbreaks. While converted mangrove had lower odds of disease occurrence compared to other previous land use for semi-intensive farms, the reverse was true for extensive farms. A farm operator did not seem to affect disease occurrence in the case of semi-intensive farms.

With extensive farms, the owner operator had lower odds of disease occurrence compared to the tenant farmer. The farms with larger total pond production areas had greater chance of disease with semi-intensive and extensive cultures (Table 2).

TABLE 2. FACTORS WITH SIGNIFICANT POSITIVE (LESS DISEASE; ODDS RATION <1.0) AND NEGATIVE (GREATER DISEASE; ODDS RATIO > 1.0) EFFECTS ON DISEASE OCCURRENCES

Sr. No. (1)	Variables (2)	Semi-intensive (3)	Extensive (4)
	Site characteristics		
1.	No. of years of shrimp farming at site	1.401	1.079
2.	Prior land use	0.104*	1.959*
3.	Farm operator	0.568	0.226*
4.	Farm area	1.954*	1.032*
5.	Source of water	0.146	1.047
6.	Salinity of intake water	0.386	2.258
7.	No. of farms within 3 kms	1.523	0.851
8.	No. of farms share water supply	0.537	0.851
9.	No. of farms discharge effluent into water supply canal	1.367*	15.354*
10.	Environmental impacts	0.366*	0.0001
	Farming systems and practices		
11.	Stocking density	1.506	0.482*
12.	Dry pond	0.046	1.576
13.	Silt removal	3.355*	1.305*
14.	Maintain or remove dykes	0.142	1.446
15.	Aeration	1.7E+12	1.178
16.	Apply chemical	0.000*	1.870
17.	Apply fertilisers	3.301	0.874
18.	Frequency of water exchange	38.35*	1.636*
19.	Discharge	11.138*	1.094
20.	Feed	42.002*	0.100
21.	No. of shrimp management/monitoring measures	0.520	0.413
22.	No. of water monitoring measures	2.333	0.507*
23.	No. of feed and cost measures	0.265	0.484*

Note: * values significant at 0.10 level.

Most of the farmers in Coastal Andhra use creek water as a source of salt/brackish water[5] for shrimp ponds. Some of the large farmers get water directly from the sea.

It was expected that farms that use creek water tend to have greater odds of disease occurrence. But in the analysis it was found that source of water does not affect disease occurrence in both the semi-intensive and extensive farms. Intake-water salinity showed no association with disease for both the culture intensities.

It was expected that farm density would increase the odds of disease occurrence. However, the number of farms within 3 kms did not show any effect for semi-intensive and extensive farms. Similarly, as expected more farms sharing a given water supply did not lead to higher disease occurrence.

On the other hand, the number of farms discharging effluent into same water supply canal lead to higher odds of disease occurrence for both semi-intensive and extensive farms.

Finally, the semi-intensive farms that took more measures during design and planning to reduce the impact on the adjacent environment had lower odds of disease occurrence but with no effect on the extensive farms. These measures include environmental-impact assessment, site selection to avoid impacts on the other users, site selection to avoid impacts of the other users, design of separate water supply/drainage canal and use of effluent treatment pond.

Farming Systems and Practices

Stocking densities did not have significant association with disease occurrence in the case of semi-intensive farms. With extensive farms, higher stocking densities had lower odds of disease occurrence. Application of chemicals showed significant association with disease occurrence in semi-intensive farms.

Pond Preparation and Water Management

Pond drying had no effect on disease with semi-intensive and extensive culture. Silt removal either exposes disease-producing sediments; or perhaps newly exposed sediments somehow stress shrimp. In both the cultures, silt removal showed negatively significant relationship with disease occurrence: in no cases silt removal was found to be beneficial. Thus farms located in areas with low sediment loads in source waters had less disease potentials.

Maintainance or repair dykes[6] showed no significant relationship with disease occurrence in both the culture systems. Usually, the farmers use aerators[7] to reduce the disease occurrence. But in this study aerators showed no significant relationship with disease occurrence in both the culture systems.

Semi-intensive farms, which applied chemicals,[8] had lower odds of disease compared to no chemical applications. In this case, chemical applications might have been a response to disease problems by the farmers. Fertiliser application showed no significant relationship with disease occurrence in both the farms.

High frequency water exchange[9] lead to higher odds of disease occurrence in both the farms. The nature of water discharge had negative or no association with disease occurrence compared with no discharge option. Thus it was found that disease organisms were perhaps re-cycled or transferred between farms more readily when farms discharge more.

Feed

While extensive systems use natural production in the ponds, the semi-intensive systems are heavily dependent on formulated feeds[10] based on fish meal and fish oils (Tacon, 1996). The semi-intensive farms that use formulated diet had greater odds of disease occurrence compared to farms with no supplementary diet. However supplemental feeding did not increase the odds of disease with extensive farms.

Regular Management Activities

It was assumed that increased management activities on a farm would decrease the chance of disease occurrence. Shrimp management and monitoring measures include regular monitoring of stock survival, daily monitoring of shrimp behaviour, and on-farm and off-farm shrimp health checks. Water quality monitoring parameters include pH/alkalinity, salinity, dissolved oxygen, nutrients (N/P), water colour and turbidity, sediment condition and quality of influent and effluent water.

Feeding and cost measures include use of feeding tray to check feed consumption, regular FCR calculations and regular production/operating cost analyses. None of these management activities seemed to affect disease occurrence in semi-intensive farms. However, more water-monitoring measures and more feeding and cost measures in extensive farms were associated with reduced disease occurrence.

Deficient environmental management of shrimp farms is the most important underlying determinant to disease outbreaks (Flegel, 1996). It is evident that environmental factors play a very important role in determining whether an infection would result in a disease or not. Management of water quality in a pond is of great importance and the most common cause of deterioration of water quality is the accumulation of wastes and generation of toxic metabolites like ammonia and hydrogen sulphide. Regular water exchange is important to prevent their formation. The microbial technology would be very useful for water quality management. During recent years, a number of products broadly labeled "probiotics" had entered the market. Some of these contain enzymes and microorganisms for improvement of the water quality.

TABLE 3. CLASSIFICATION OF DISEASE OCCURRENCE

			Predicted		
			Disease occurrence		
(1)	Observed (2)		< 20 per cent (3)	≥20 per cent of crop (4)	Percentage correct (5)
Step 1	Disease occurrence	< 20 per cent	17	2	89.5
		≥ 20per cent of crop	3	48	94.1
	Overall percentage				92.9

IV

CONCLUSIONS AND POLICY IMPLICATIONS

Shrimp disease is a major constraint on shrimp aquaculture production. The prevention of disease outbreaks will improve the financial viability of the shrimp industry and reduce many of the environmental and socio-economic concerns. In the local pond environment, the most realistic approach to combat diseases will be combining careful site selection, good pond management and the use of prophylactic agents.

In the analysis, the factors associated with higher odds of disease occurrence were found to be silt removal between crops versus no removal, larger area of production ponds and larger number of farms discharging pond effluents into water supply canals. While the factors associated with lower odds of disease occurrence were taking water from the sea through a canal versus from a saltwater creek. Logistic regression analyses provide meaningful insights into causal relationships between shrimp disease problems and shrimp culture practices. Thus the analyses can be of a considerable value to shrimp researchers and policy makers.

Careful site selection with good pond management and the use of prophylactic agents is the most realistic approach to combat diseases. Farmer groups if formed can play a very important role in managing the source water quality and the local environment. They can discuss common actions that can be taken during disease outbreaks on a priority basis, to avoid spreading of disease from one farm to another. The polluter-pays principle may be applied so that the farmers who do not comply with environmental standards are charged for their own environmental impact.

Received February 2005. *Accepted April 2006.*

NOTES

1. Shrimp/prawn farming is the process of growing the baby prawns up to a marketable size in an enclosed water body. The prawns/shrimps are aquatic organisms inhabiting sea, estuaries and backwaters. They are produced from these water bodies by fishing or farming.

2. In extensive shrimp aquaculture, locally prepared feeds are used. These systems require minimal management of water parameters, because they usually operate without aerators or pumps for water exchange. Disease outbreaks are rare, due to low stocking densities (1-3 shrimp/m^2) and no supplementary feeding. Land and labour are the principal inputs, which keeps operational cost at a minimum.

3. Semi-intensive cultivation involves stocking densities beyond those that the natural environment can sustain without additional inputs. Farmers depend on formulated feeds to augment natural food in the ponds. Costs associated are much higher than the extensive systems.

4. White spot disease (WSD), the dominant shrimp disease problem is caused by the white spot syndrome virus (WSSV) and affects shrimps of all age groups. The risk of disease increases with intensity of farming and thus density of shrimp in the pond. Best management practices constitute a critical instrument in disease prevention, since the environmental quality of both the ponds and the surrounding waters has a strong influence on disease prevalence.

5. Brackish water is a mixture of sea water and fresh water with salinity of 15 to 30 PPT (parts per thousand). Generally 4 to 5 feet depth of brackish water will be maintained in the pond.

6. Generally four-fifth of area will be pond or watershed area and the rest will be used for establishment of dykes and bunds.

7. Aerators are the equipments used for providing sufficient oxygen in the water of pond for healthy growth of the prawn.

8. Excessive and unwanted use of chemicals in shrimp culture results in toxicity to non-target species, development of antibiotic resistance and accumulation of residues. Antibiotic use reduces natural microbial activity, which leads to waste accumulation and reduced degradation and nutrient recycling. This results in loss of buffer capacity and ecological resilience.

9. After 15-30 gm stage of Post Larvae (PL), it is advisable to resort to water exchange at 20-30 per cent level. Where stocking densities will be more as in semi-intensive culture, the need for water exchange will be more.

10. Generally 1-1.5 kg of feed for one lakh stocking density is given on day one and it is recommended that the feed quantity be increased by 400-600 gm per day for the same density till 30 days. Feed rate from then on is to be calculated depending on the survival rate and average body weight. Artificial feed which is a mixture of fish meal, rice bran, oil cake, blood meal etc., produced in the form of small pellets in the feed mills is used as prawn feed. Different feeds like Avanti, CV were available in the market based on the contents used and quality.

REFERENCES

Balaji, R. (1999), "A.P. Shrimp Industry Hits Rough Patch", *The Business Line*, July 13.

Greene, W.H. (1990), *Econometric Analysis,* Macmillan Publishing Company, New York.

Flegel, T. (1996), "A Turning Point for Sustainable Aquaculture: The White Spot Virus Crisis in Asian Shrimp Culture", *Aquaculture Asia*, July-September, pp. 29-34.

Hein (2000), "Impact of Shrimp Farming on Mangroves along India's East Coast", *Unasylva*, Vol.203, No.51, pp. 48-55.

Johnson-Iferulundu, Y.J. and J.B. Kaneene (1998), "Management-Related Risk Factors for M. Paratuberculosis Infection in Michigan, U.S.A., Dairy Herds", *Preventive Veterinary Medicine*, Vol.37, pp. 41-55.

Le Moullac, G; C. Soyez; D. Saulnier; D. Ansquer; J.C. Avarre and P. Levy (1998), "Effect of Hypoxic Stress on the Immune Response and the Resistance to Vibriosis of the Shrimp *Penaeus* Stylirostris", *Fish and Shellfish Immunology*, Vol.8, pp. 621-629.

Leung, P.S. and L.T. Tran (2000), "Predicting Shrimp Disease Occurrence: Artificial Neural Networks vs. Logistic Regression", *Aquaculture*, Vol.187, pp. 35-49.

Leung, P.S.; L.T. Tran and A.W. Fast (2000), "A Logistic Regression of Risk Factors for Disease Occurrence on Asian Shrimp Farms", *Diseases of Aquatic Organisms*, Vol.41. pp. 65-76.

Lundin, C.G. (1995), *Global Attempts to Address Shrimp Disease*, Land, Water and Natural Habitats Division, Environment Department, The World Bank, Washington, D.C., U.S.A., pp. 1-44.

Menard, S. (1995), *Applied Logistic Regression Analysis*, Sage Publications, Thousand Oaks.

MPEDA/NACA (2003), "*Shrimp Health Management Extension Manual*, Prepared by the Network of Aquaculture Centres in Asia-Pacific (NACA) and Marine Products Export Development Authority (MPEDA), India, in co-operation with the Aquatic Animal Health Research Institute, Bangkok, Thailand; Siam Natural Resources Ltd., Bangkok, Thailand; and AusVet Animal Health Services, Australia. Published by the MPEDA, Cochin, India.

Pe, T. and P.T. Smith (1999), *In Search of Variables Contributing to Production of Shrimp and Identifying Shrimp Farming Provinces in Thailand-Coastal Shrimp Aquaculture in Thailand: Key Issues for Research*, ACIAR Technical Reports Series 47, pp. 69-83.

Ronnback, P. (2001), *Shrimp Aquaculture – State of the Art,* Swedish EIA Centre, Report 1, Swedish University of Agricultural Sciences (SLU), Uppsala. (ISBN 91-576-6113-8).

Spaargaren, D.R. (1998), "Cultivation of Tiger Prawns, *Penaeus Monodon, Fabricius*, 1798 (Decapoda, Natantia) in Hainan, P.R. China", *Crustaceana*, Vol. 71, pp. 144-157.

Tacon, A.G.J. (1996), "Feeding Tomorrow's Fish", *World Aquaculture*, Vol.27, pp. 20-32.

APPENDIX

LIST OF EXPLANATORY VARIABLES

Sr. No. (1)	Variable (2)	Variable type (3)	Variable description (4)
	Site characteristics		
1.	No. of years of shrimp farming at site	C	
2.	Prior land use	N	1: mangrove land; 2: rice farming; upland crops; 4: other
3.	Farm operator	N	1: owner; 2: lease/tenant
4.	Farm area	C	ha
5.	Source of water	N	1: saltwater creek; 2: estuary/river; 3: direct from sea; 4: canal from sea; 5: other
6.	Salinity of intake water	N	1: within the range of 5-35 ppt; 0: otherwise
7.	No. of farms within 3 kms	C	
8.	No. of farms share water supply	C	
9.	No. of farms discharge effluent into water supply canal	C	
10.	Measures taken to reduce Environmental impacts	C	
	Farming systems and practices		
11.	Stocking density	C	PL/m2
12.	Dry pond	N	1: yes; 0: no
13.	Silt removal	N	0: no silt removal; 1:flushing, deposit silt on-farm; 2: flushing, deposit silt off-farm; 3: flushing, deposit silt on and off farm; 4: mechanical or manual removal
14.	Maintain and repair dykes	N	1: yes; 0: no
15.	Aeration	N	1: yes; 0: no
16.	Apply chemical	N	1: yes; 0: no
17.	Apply fertilisers	N	0: no; 1: inorganic; 2: organic; 3: mixed – inorganic and organic
18.	Frequency of water exchange	C	times/month
19.	Discharge	N	0: no discharge; 1: discharge to settlement pond; 2: discharge to drainage canal; 3: discharge to intake/drainage canal; 4: reuse water on farm; 5: mixed – some forms of discharge
20.	Feed	N	0: no supplemental feeding; 1: simple diet; 2: formulated diet; 3: mixed
21.	No. of shrimp management/monitoring measures	C	0-4 depending on number of activities
22.	No. of water monitoring measures	C	0-8 depending on number of activities
23.	No. of feed and cost measures	C	0-3 depending on number of activities