THESIS

DEVELOPMENT OF SAFETY AND QUALITY MANAGEMENT SYSTEM IN SHRIMP FARMING

Submitted to

COCHIN UNIVERSITY OF
SCIENCE AND TECHNOLOGY

In partial fulfillment of
the requirements for the award of the Degree of
Doctor of Philosophy

by

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JANUARY, 2009

Dedicated to the Shrimp farmers of Kerala

DECLARATION

I, Ancy Sebastian, hereby declare that the thesis entitled "Development of Safety and Quality Management System in Shrimp Farming" is based on the original research work carried out by me under the guidance and supervision of Prof. (Dr.) A. Ramachandran, Reader, School Of Industrial Fisheries, Cochin University of science and Technology, Cochin-16, and no part of this work has previously formed the basis for the award of any degree, assessment, or any other similar title or recognition.

Date :07.01.2009

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Certificate

This is to certify that this thesis entitled "Development of Safety and Quality Management System in Shrimp Farming" is an authentic record of research work carried out by Smt. Ancy Sebastian under my guidance and supervision and no part of this work has previously formed the basis for the award of any degree, assessment, or any other similar title or recognition.

Date: 07.01.2009
Place : Cochin-16

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LIST OF ABBREVIATIONS

ACC- Aquaculture Certification Council

ADB - Asian Development Bank

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AQIS - Australian Quarantine Inspection Service

BMP- Best Management Practices

BOD- Biochemical oxygen demand

CAC - Codex Alimentarious Commission

CB-CRM –Community Based Coastal Resources Management

CBD-Convention on Biological Diversity

CCPs - Critical control points

CFP - Carbon Foot Print

CPs - Control points

CCRF -Code of Conduct for Responsible Fisheries

CFH - Committee on Food Hygiene

CRZ - Coastal Regulation Zone

CSPI-Center for Science in the Public Interest

DLC- District Level Committee

EEZ- Exclusive Economic Zone

EIA -Environmental Impact Assessment

EIFAC-European Inland Fisheries Advisory Commission

EMS- Environment management systems MPEDA

ETS- Effluent Treatment System

EU - European Union

FAO - Food and Agriculture organisation

FDA – Food and Drugs Administration

FSIS-Food safety and Inspection services

FSO-Food Safety Objectives

GAA -Global Aquaculture Alliance

GATT- General Agreement on Tariffs and Trade

GHP-Good hygienic practices

GLP - Good laboratory practices

GMP-Good manufacturing practices

HACCP - Hazard Analysis Critical Control Points

HAZOP - Hazard Opportunity Studies

HPV-Hepatopancreatic Virus

ICAR - Indian Council of Agricultural Research

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ICES - International Council for the Exploration of the Seas

ICMSF-International Commission on Microbiological Specification for Foods

ICZM -Integrated Coastal Zone Management

IHHNV Infectious hypodermal and hematopoietic necrosis virus

ILSI-International Life Science Institute

IPQC -In-process quality control

MBV - Monodon baculovirus

MIPQC-Modified in-process quality control

MSSP-Model Seafood Surveillance Project

NACA- Network of Aquaculture Centres in Asia and the Pacific

NACMCF-National Advisory Committee on Microbiological Criteria for Foods

NASA - National Aeronautics and Space Administration

NAS-National Academy of Sciences

NGOs -Non-government organizations

NMFS-National Marine Fishreies Service

NOAA-National Oceanic and Atmospheric Administration

NSIL-National Seafood Inspection Laboratory

PCR-Polymerase chain Reaction

PL – post larvae

PRP - Pre requisite programs

QAAD-Quarterly Aquatic Animal Disease Reporting System

QAMS-Quality Assurance and Monitoring System

QCIA-Quality Control and Inspection in Approved units

QMP - Quality management program

PREFACE

This thesis, "Development of Safety and Quality Management System in Shrimp Farming" is the outcome of the search for improving and assuring the quality and safety of aquacultured shrimp. The model designed in the present study is a united approach to safety and quality based on the concepts of HACCP and PRP for guiding the shrimp farmers, hatchery operators and the HACCP practitioners through the HACCP process.

Chapter 1 presents the importance of aquaculture in general and shrimp culture in particular, background and rationale of the present study and closes with a brief mention on the scope and objectives.

Chapter 2 reviews the development of shrimp farming in Asian region and India, BMPs in aquaculture, role of aquaculture legislation, status of hatcheries and the constraints faced, history of food safety and origin of HACCP, development of HACCP in different countries, the farm to table food safety, genesis of the PRP, need for HACCP and PRP and the development of safety and quality management systems.

Chapter 3 discusses the methodology used for the HACCP and PRP surveys and physico-chemical and bacteriological analyses.

Chapter 4 approaches the shrimp farmers, evaluates their knowledge with respect to HACCP and PRP concepts through questionnaires and other means and understands the challenges faced by them. The study indicated that even though the HACCP awareness was poor, most of the shrimp farmers were found to have a significant amount of knowledge in good aquacultural practices and the PRP adherence was also found satisfactory.

Chapter 5 investigates the impact of farming environments and practices on the quality and safety of farmed shrimp and indicated that though the shrimp were cultured in unpolluted waters and were safe for consumption better care need to be taken.

Chapter 6 explores the knowledge, attitude and adherence of the hatchery operators to HACCP and PRP, identifies the constraints faced and found that the awareness of the hatchery operators was higher compared to the shrimp farmers and proper pre requisite hatchery practices were often followed in most of the hatcheries studied.

Chapter 7 develops the PRP model encompassing all the activities which may interact and influence the final safety outcome of the product and the process control model representing the centre of activities of a shrimp farm incorporating the CCPs. The combined safety and quality management model holds the PRP at the boundary and the process control at the centre which explains how HACCP and PRP can support each other and co-exist in a system.

Chapter 8 attempts to identify the various steps and the factors involved in the hatchery production of *P.monodon* postlarvae, differentiate the CCPs and CPs, segregate the HACCP and PRP aspects to unite and arrange them on a quality management wheel for the overall quality and safety management of the shrimp hatchery operations.

Chapter 9 summarizes, gives recommendations and concludes the thesis followed by a list of references.

It was a long felt need of the seafood exporters, shrimp farmers and hatchery operators of our country, for a good and transparent source of information useful for application in their production process regarding the safety and quality management issues. Realizing the inefficiency of HACCP as a stand alone system, a multidisciplinary approach to food safety and quality by combining the concepts of HACCP and PRP and managing both HACCP and PRP within a quality management system has been tried in this study. This study becomes significant in the present context of repeated grow out failures, deteriorating quality of hatchery produced seeds and continuing threat of safety problems on our cultured shrimp. Understanding such an urgent need, this study was taken up and it is hoped that this will inspire the concerned authorities to serve the purpose.

ANCY SEBASTIAN

ACKNOWLEDGEMENTS

I wish to express my sincere thanks and deepest sense of gratitude to my guide Dr. A Ramachandran, Reader, School of Industrial Fisheries, Cochin University of science and Technology for the unfailing guidance, invaluable suggestions, critical assessment and constant encouragement throughout the course of my work.

I am grateful to Dr. K.Devadasan, former Director, Central Institute of Fisheries Technology, Cochin, for granting me study leave to carry out this study. I wish to express my sincere thanks to Dr.M.K.Kandoran, former Principal Scientist of CIFT, for introducing me into the field of fisheries research.

My sincere thanks are also due to Dr.T.S.Gopalakrishna Iyer, former Principal Scientist of CIFT, for his valuable guidance and constant encouragement throughout my career. I am grateful to Dr.Jose Joseph, Principal Scientist, CIFT, for correcting the manuscript and giving valuable suggestions.

I wish to express my sincere thanks to Dr.M.K. Mukundan, Head,QAM Divivsion, CIFT, for his valuable help for granting me study leave. I am also grateful to Shri. P.R.Girija Varma, Dr.Francis Thomas, and other scientists of QAM division, for the research activities of the division has always been a source of inspiration for me. I wish to extend my wholehearted thanks to my colleagues in QAM division who patiently shared the works I had been doing, during the period of my study leave.

My sincere thanks are also due to Dr.B.Meenakumari, Director, CIFT and other scientists and staff of Fishing Technology Division.

I specially place on record the encouragement and support offered by Dr.B.Madhusudhana Kurup, Director, School of Industrial Fisheries, CUSAT, and Dr.Ramakrishnan Korakandy, Dr.K.T.Thomson, Dr.Saleena Mathew, Dr.John Mohan and other Faculty members of School of Industrial Fisheries, for their critical assessment and valuable suggestions especially during my pre synopsis presentation.

Thanks are also due to Shri.H.Krishna Iyer, Principal Scientist, CIFT, for his valuable advice on data analysis and Dr.V.Geethalakshmi, senior scientist, CIFT for carrying out the data analysis.

I wish to extend my wholehearted thanks to Dr.Basak, Dr.Sosamma Easo, Dr.Sreedevi, Shri.Vinod and Shri.Natarajan of MPEDA, Cochin for guiding me during the field visits and providing the laboratory facilities.

I wish to express my sincere thanks to the Zonal Directors and Deputy Directors of State Fisheries Department, Officers and staff of Matsyafed and ADAK for the immense help and information offered to me. My sincere thanks are also due to the seafood exporters and the shrimp farmers and hatchery operators in Thrissur, Kochi, Alappuzha, Kollam and Kannur districts of Kerala.

My sincere thanks are also due to the administrative staff of School of Industrial Fisheries and Head office, CUSAT, whose timely help was very much valuable for the accomplishment of this thesis.

In addition, the encouragement and support extended by my family members and well wishers is also gratefully acknowledged.

Above all, I thank the Almighty for leading me without fall all through the stormy waves and cloudy waters.

ANCY SEBASTIAN

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BACKGROUND

Shrimp Aquaculture has provided tremendous opportunity for the economic and social upliftment of rural communities in the coastal areas of our country. Over a hundred thousand farmers, of whom about 90% belong to the small and marginal category, are engaged in shrimp farming. *Penaeus monodon* is the most predominant cultured species in India which is mainly exported to highly sophisticated, quality and safety conscious world markets. Food safety has been of concern to humankind since the dawn of history and the concern about food safety resulted in the evolution of a cost effective, food safety assurance method, the Hazard Analysis Critical Control Point (HACCP). Considering the major contribution of cultured *Penaeus monodon* to the total shrimp production and the economic losses encountered due to disease outbreak and also because traditional methods of quality control and end point inspection cannot guarantee the safety of our cultured seafood products, it is essential that science based preventive approaches like HACCP and Pre requisite Programmes (PRP) be implemented in our shrimp farming operations. PRP is considered as a support system which provides a solid foundation for HACCP. The safety of postlarvae (PL) supplied for brackish water shrimp farming has also become an issue of concern over the past few years. The quality and safety of hatchery produced seeds have been deteriorating and disease outbreaks have become very common in hatcheries. It is in this context that the necessity for following strict quarantine measures with standards and code of practices becomes significant. Though there were a lot of hue and cry on the need for extending the focus of seafood safety assurance from processing and exporting to the pre-harvest and hatchery rearing phases, an experimental move in this direction has been rare or nil. An integrated management system only can assure the effective control of the quality, hygiene and safety related issues. This study therefore aims at designing a safety and quality management system model for implementation in shrimp farming and hatchery operations by linking the concepts of HACCP and PRP.

Chapter - 1
INTRODUCTION

1.1 General Introduction

The increasing world population and awareness on the nutritional advantages of consumption of fish are the causes for the ever increasing demand for fish. Fisheries play a vital role in supplementing the protein food requirements at an affordable cost in addition to providing a lot of employment opportunities. The marine fisheries sector of the country is witnessing an era of declining production. However, the growth rate in the inland fish production which includes aquaculture was showing a high increase in volume. Even though the heavy responsibility of filling up the gap from capture fishery put on aquaculture resulted in a rapid increase in aquaculture production, it did not last long. Environmental and social conflicts along with disease outbreaks resulted in a sudden decline and almost stagnant situation in marine shrimp farming. *Penaeus monodon* is the most predominant cultured species in India which is mainly exported to highly sophisticated, quality and safety conscious world markets. There were instances of rejections and detentions due to various safety and quality problems like presence of antibiotic residues, pesticides and undesired chemicals and muddy and moldy smell in cultured shrimp in certain regions. It is well understood that the traditional methods of quality control and end point inspection cannot guarantee the safety of cultured seafood products and so in order to ensure the superior quality of our cultured shrimp products and to sustain the world markets, it is essential to identify the potential food safety hazards at the primary production stage of the food chain itself and control them to the safety level to eliminate the chances of detecting a hazard at later stages of the food chain. The need for aquaculture to improve its public image in the face of mounting criticism has also become urgent. The impact of aquaculture on the environment as well as the environmental conditions on aquaculture, both factors have to be taken into account. The sporadic incidences of disease outbreaks and some isolated incidents of social conflicts also have reasserted the need for adoption of better management measures for conducting shrimp culture in an environmentally, socially and economically sustainable manner. The application of a Science-based approach, based on the principles of HACCP was recommended by many experts as a remedy for overcoming such problems.

The rapid development of shrimp farming in our country was due to the setting up of a large number of modern shrimp hatcheries and assured supply of quality seed. Wild-caught broodstock, one fourth of which are reported to be White Spot Syndrome Virus (WSSV) positive is the only source of shrimp seed even today. Over the past few years, the safety and quality of hatchery produced seeds have been deteriorating and disease outbreaks have become very common in hatcheries despite the presence and use of standards and code of practices such as Good Management Practices (GMP), specifications for seeds and requirements for the facility etc.formulated by the regulatory authorities. Successful grow out operations and hence the future of the shrimp farming industry depends upon abundant supplies of high quality seed which in turn depends upon the quality of nauplii and the hatchery management practices followed. Considering the major contribution of *Penaeus monodon* to the total shrimp production and the economic losses encountered due to disease outbreaks, it is essential that better management measures, Science based preventive approaches like HACCP and PRP be implemented in our shrimp hatcheries and shrimp farms. Researchers and regulatory agencies alike have advocated the extension of HACCP concept from processing and exporting to the shrimp farming and hatchery sectors.

Several studies have assessed the possibility of application of hazard analysis and risk management procedures into aquaculture production. These studies looked into food safety issues associated with products from aquaculture and found that there were considerable need for information and the knowledge gaps hinder the process of risk assessment and the application of risk management strategies with respect to food safety assurance for products from aquaculture. Such studies recognized the difficulties in applying HACCP to small scale farming systems and found that food safety hazards associated with aquaculture vary by regions, habitat and environmental conditions as well as methods of production and management, identified the farm level risk factors and evolved practical management practices that can be used to reduce risks of shrimp disease outbreaks and improve farm production.

The worldwide evaluation and reorganization of food inspection and control systems geared towards improving efficiencies, rationalizing human resources and introducing risk analysis-based approaches resulted in the convergence towards the necessity to implement a preventative approach based on the HACCP principles and away from the traditional approach that relied heavily on end-product sampling and inspection and that is HACCP. Several researchers have pointed out that formal PRP are needed to support the implementation of HACCP. Even though a good amount of literature is available projecting the role of HACCP as a food safety assurance system and PRP as a support system for HACCP, reports indicating the importance of an integrated approach to food safety and quality are not many. Few studies have pointed out that there exists a big confusion between PRP and HACCP plan, their relations and how they should be managed mainly because of negative guideline factors and lack of understanding. In the present study, a review of the food safety literature and discussions with the shrimp farmers, hatchery operators and HACCP practitioners regarding hazard analysis, also identified similar situations which urged the need for a model which could guide the beneficiaries through the HACCP process. Realizing the inefficiency of HACCP as a stand alone system, a multidisciplinary approach to food safety and quality by combining the concepts of HACCP and PRP and managing both HACCP and PRP within a quality management system has been tried out in this study. A model has been designed, by consolidating various concepts from similar models which can be adopted as a generic model for safety and quality management in shrimp farming and hatchery operations.

There have been no studies examining the possibility of implementing PRP and HACCP as well as the extent to which the safety programmes are implemented in shrimp farming and hatchery operations in Kerala. The very limited research in this area forced me to take up this study. It is anticipated that the present work may give useful information to the shrimp farmers, hatchery operators and other stakeholders. This study becomes significant in the present context of repeated grow out failures, deteriorating quality of hatchery produced seeds and continuing threat of safety problems on our cultured shrimp.

1.2 Objectives

The objective of this study is to determine the extent of adherence of the shrimp farmers and shrimp hatchery operators to the principles of HACCP and PRP. The study aims at improving the methods practiced so as to ensure product safety, economic efficiency and fair trade practices. This study explores the current shrimp farming and hatchery practices, evaluates adherence to HACCP and PRP principles, identifies the various steps and factors involved in shrimp aquaculture production and hatchery production of *P.monodon* postlarvae, differentiate the control points (CPs) and critical control points (CCPs), segregate the HACCP and PRP aspects and identifies the barriers which are obstructing the implementation of HACCP and PRP in shrimp farming and hatchery operations. The purpose of this research is to evaluate current shrimp farming and hatchery management practices, assess farmer's and hatchery manager's knowledge and attitudes about shrimp farming and hatchery operations and to design a safety and quality management system model for implementation in shrimp farming and shrimp hatchery operations respectively.

This study is conducted with the following objectives:

- To study the status of the existing quality and safety control systems in the shrimp farming and hatchery industries in Kerala.
- To study the information needs of the shrimp farming and hatchery sectors.
- To study the quality, safety and other issues pertaining to the farming and hatchery operations.
- To study the impact of farming conditions and practices on the quality and safety of shrimp cultured.
- To identify the barriers and assess the possibilities of introducing PRP and HACCP in shrimp farming and hatchery operations.
- To develop models of safety and quality management system for implementation in shrimp farming and shrimp hatchery industries.

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Chapter - 2

REVIEW OF LITERATURE

2.1 Introduction

The world population is on the increase, as is the demand for aquatic food products. Fish constitute one of the major protein sources for humans around the world. Production from capture fisheries at a global level is levelling off. Potential contributions from aquaculture to local food security, livelihoods and nutrition can be highly significant, especially in many remote and resource-poor rural areas (Subasinghe 2005). There are to date 25 000 different known fish species of which 15000 are marine and nearly 10 000 are freshwater. Despite the abundance and variation of fish, most western fisheries focus on a few target species. Approximately 75% of the world's marine fish landings consist of 200 known existing marine fish species. In 1995, 139 million tonnes of fish were harvested by capture fisheries and produced in aquaculture, and the average global food fish supply reached a record high level of 14 kg per capita (Holmlund and Hammer 1999). The global average per capita consumption of fish and fishery products in 2007 reached 16.9 kg compared to 14.8 kg in 1990s'. In India, the average per capita consumption of fish is still below the world average due to lower intake in central and northern areas. Japan's per capita consumption of fish declined from over 70 kg to 62.7 kg (Anon 2007) while the per capita fish consumption in China increased from 13.5kg in 1990s' to 26kg in 2006 (Ferdouse 2008). Today, there is heightened concern about the state of the world's oceans when three-quarters of global fish stocks are fully or over-exploited. Fish provides almost 20% of global animal protein consumed by humans (Deutsch et. al. 2000). The demand for fish is expected to rise substantially by 2020. Several coastal fisheries no longer provide their potential benefits for two reasons: spawning biomass has been reduced below optimal levels, and the habitats that support fisheries production have been degraded (Bell et al. 2006). At the same time, it is doubted whether aquaculture can increase global food security or if it, instead, will increase demand on other fish species as inputs to aquaculture feed, thus reducing overall protein available for human consumption. Biological estimates clearly indicate that natural fishery resources are depleted to a fraction of former standing stocks. Thus, the likelihood that fisheries production will remain important for national economies in the future is remote, and it seems unlikely that a fishery industry can continue to keep up with a growing domestic demand for fish. An estimated 65 million people in Southeast Asia remain under nourished (Mulekom et al. 2006).

Aquaculture is the fastest growing food-producing sector in the world. A great proportion (over 90%) of this production comes from the developing world. Aquaculture continues to grow more rapidly than all other animal food-producing sectors. Worldwide, the sector has grown at an average rate of 8.9% per year since 1970, compared with only 1.2% for capture fisheries and 2.8% for terrestrial farmed meat production systems over the same period. Cultured seafood production (not including aquatic plants) has increased more than seven-fold by weight (from 5 to 36 million tonnes between 1980 and 2000 and the value generated has grown from US$ 9 billion in 1984, to US$ 52 billion in 2000. In 1990, approximately 25% of the world's shrimp production came from shrimp farming. Today, about 30% of global shrimp consumption is supplied by aquaculture (Deutsch et al. 2000). Even today, aquaculture provides over a quarter of the world's seafood supply, a figure the Food and Agriculture organization (FAO) xpects to approach 50% by the year 2030. With the diminishing availability of freshwater, most of this growth will take place in seawater. The majority of aquaculture production of fish, crustaceans and molluscs continues to come from the freshwater environment (57.7% by volume and 48.4% by value). Mariculture contributes 36.5% of production and 35.7% of the total value. Although brackish water production represented only 5.8% of production volume in 2002, it contributed 15.9% of the total value reflecting the prominence of high-value crustaceans and fin fish. Aquaculture is a significant socio-economic activity, especially for rural communities, contributing to livelihoods, food security and poverty alleviation through such mechanisms as income generation, employment, services, use of local resources, diversified farming practices, domestic and international trade and other economic investments serving the sector. The common carp culture in China as early as 1100 B.C, oyster farming during the Han Dynasty in 206 B.C.–220 A.D, the Japanese culturing oysters for pearls, ancient Egyptians stocking ponds with fish, the Greeks and Romans raising eels and the Europeans cultivating oysters, etc. are records of early aquaculture practices. Since time immemorial, the coastal zone has been a center of human activity because of its high biological productivity and easy accessibility. Close to half of the world's population resides within 100km of the coastline. The aquaculture sector is highly diverse in terms of species, culture systems, culture environment, type of operation and scale, intensity of practice and type of management (Reantaso et al. 2005).

2.1.1 Development of Shrimp Farming in the Asian Region

Commercial shrimp farming started in the early seventies and today, over fifty countries export farmed shrimp. The leading aquaculture producers by rank were China, India, Vietnam, Thailand, Indonesia and Bangladesh (Ferdouse 2008). China, even though originally started with freshwater aquaculture, when it came to the realization by the Chinese Government that shrimp farming was the only alternative for productive utilization of vast tracts of arid saline- alkaline coastal flat lands, the Government took a macro-approach which resulted in a huge increase in Chinese shrimp farming. Shrimp farming is steadily increasing in other countries such as Vietnam and Bangladesh. Thailand has been one of the top producers of farmed shrimp from 1993 onwards. The sea water irrigation system provided by the Government of Thailand facilitates supply of clean sea water to individual farms. About 80% of the shrimp farms are owned by small-scale farmers operating in ponds ranging in size from 0.16-1.6 ha. Extensive, semi-intensive and intensive types of farming systems are presently practiced in the country. Ecuador, a major shrimp producing country outside Asia, rose to the top position as early as 1984. Although all the Latin American countries from Mexico to Peru produce shrimp, Mexico, Honduras and Columbia are the major producers. Philippines witnessed its peak shrimp production in 1993 with giant tiger shrimp as the major contributor, however, the total shrimp production fell largely due to shrimp disease in 1997, which made them try out with lower densities, pro-biotics pond bioremediation techniques as well as mixed culture practices. In the Middle-East, Saudi Arabia along the Red Sea and Islamic Republic of Iran along the Persian Gulf are the large-scale shrimp farmers mostly stocking *P.indicus*. Other countries in the region engaged in commercial shrimp farming are UAE, Kuwait and Yemen (AAI 2002).

The technological advances of Asian shrimp farming systems have not only contributed to a rapid expansion of Asian shrimp culture, but have also created greater opportunities for foreign exchange earnings in the 1980s and 1990s (Ling et al. 1999). The Asian region accounted for more than 60% of global shrimp exports since 1985. By 1994, almost 30% of the global shrimp supply came from aquaculture operations, of which 82% was provided by Asian producers. Thereafter, competition significantly increased in world shrimp markets as many Asian countries initiated or expanded shrimp culture (Ling et al. 1999). Shrimp aquaculture reached 3.6 million mt in 2006, of which 2.13 million mt were *P.vannamei*. Production of farmed fish increased from 35.5 million mt in 2000 to 52 milion mt in 2006 (Ferdouse 2008). *P. monodon, P. indicus, L.vannamei, P. orientalis, P. merguiensis, P. japonicus and Metapenaeus species* are the major species cultured. Oversupply of cultured shrimp products occurred in the global market in the 1990s. Consequently market price of shrimp have dropped and profit margins have been squeezed by export markets (Ling et al.

1999). Shrimp farms are broadly classified into three types based on major economic and technological considerations: intensive, semi-intensive and extensive systems. Stocking and feeding rates determine whether the operation is classified as extensive, semi-intensive or intensive shrimp farming. Monoculture dominates in intensive and semi-intensive farming systems whereas both monoculture and polyculture methods are commonly used in the extensive culture. There is a higher diversity of culture shrimp species in extensive farming systems. The dominant intensive and semi-intensive shrimp species cultured in India is *Penaeus monodon* followed by *Penaeus indicus* (Ling et al. 1999). The average farm size of intensive shrimp farms ranged between 2.0 ha in Thailand and 19.8 ha in India. With regard to the semi-intensive system, Indian farms averaged about 6.4 ha and Chinese farms which are by far the largest of the semi-intensive producers, often run by co-operatives averaged about 24.9 ha. The farm size of extensive shrimp farms averaged 12.6 ha and varied from 1.2 ha in India to 39.5 ha in China. The stocking density of extensive farms is very low, ranging from 0.0 PL /m^2 in Thailand to 7.9 PL/m^2 in China. Significant reduction in the use of feed was the important feature of the extensive system, as compared to intensive and semi-intensive systems. Consequently, the feed conversion ratio is also low. The cost comparison studies by Asian Development Bank (ADB) and Network of Aquaculture Centres in Asia and the Pacific (NACA), (1996) revealed that the profit was higher for Indian extensive shrimp farms (2.77 US$ per kg) whereas the profit for intensive and semi-intensive shrimp farms was 1.6 US$ and 1.31 US$ per kg respectively (Ling et al. 1999).

2.1.2 Development of Shrimp Farming in India

India is the second largest shrimp producing country after China (Ferdouse 2008). India, by virtue of its 8 118 km long coastline, 2.02 million sq. km of Exclusive Economic Zone (EEZ) and extensive geographical stretch with varied terrain and climate, supports a wide diversity of inland and coastal wetland habitats. It has been estimated that there is 3.9 million ha of estuaries and 3.5 million ha of brackishwater areas in the country. Out of this, 1.2 million ha of coastal area has been identified as suitable for brackishwater aquaculture and through the use of sustainable practices this resource can yield optimum quantities of shrimp and other commercially valuable fin and shell fish species Aquaculture Authority of India AAI (2002). Shrimp farming is viewed as a sound option to increase fish production, as the harvest from capture fisheries has stagnated. In India, commercial shrimp farming started only during the eighties, much later than the other shrimp producing Asean countries. At present the contribution of shrimp to the total fisheries exports is about 66% by value and 29% by quantity. Brackish water aquaculture in India, is presently restricted to shrimp farming because of high export value of penaeid shrimp, the main shrimp species produced being *Penaeus monodon* which is cultured in 1.54 lakh ha with a national productivity of 730kg/ha/annum (Kumaran et al. 2008). The uncontrolled growth of the shrimp farming activities has led to disease outbreaks, environmental degradation etc. threatening the long-term sustainability of shrimp aquaculture itself. However, India is still considered as a sleeping giant in aquaculture production as it has a vast potential area for aquaculture development. Presently only 13% of the total brackish water area (1.19 mha) is under aquaculture. The first step for scientific and sustainable development of brackish water shrimp culture is better site selection followed by improved culture management (Karthik et.al. 2005)

In India, shrimp farming has been traditionally practiced in the coastal states of Kerala and West Bengal. The traditional trap and culture system comprised mixed species of fin and shell fishes and was characterized with low production levels. The shrimp farming areas are mainly located in the coastal states of Gujarat, Mahaarashtra, Karnataka, Goa Kerala, Tamil Nadu, Andhra Pradesh, Orissa and West Bengal. The importance of introducing scientific farming techniques to increase production and productivity from the traditional system was felt and the Indian Council of Agricultural Research (ICAR) implemented an All India Coordinated Research Project on Brackishwater Fish Farming (1973-1984) to develop and test various farming technologies under different agro-climatic conditions of the country. This project was helpful in demonstrating the technologies to the small scale farmers through its main center at West Bengal and other centers at Orissa, Andhra Pradesh, Tamil Nadu, Kerala and Goa. Simultaneously, shrimp hatchery technology was also introduced into the country and two commercial hatcheries were established in the late eighties. The Government of India, in 1991, issued a major notification under the Environment Protection Act, 1986, framing rules for regulation of various coastal zone activities, the Coastal Regulation Zone (CRZ) rules. Under these Rules, the entire coastal stretch from the lowest low tide to highest high tide line and the coastal land within 500m from the high tide line on the landward side is termed as CRZ. No reclamation of kayals (backwaters) will be permitted within the CRZ areas and many construction and developmental activities have been restricted, however, hatchery and natural fish drying is permitted. The country witnessed a faster development of shrimp farming between 1990 and 1994 with the establishment of more hatcheries in the private sector. The culture practice was also intensified with increased investment and stocking densities. *Penaeus monodon* was and still the most predominant cultured species in India. Shrimp culture was affected by health and disease problems starting with the initial attack of bacterial diseases which were localized and the mortality rate was not very high. The devastating viral diseases such as Monodon Baculovirus (MBV) and WSSV in 1995 affected the industry and there was considerable decrease in shrimp farming soon afterwards. Heavy stocking densities and poor farm management practices were the reasons attributed to the shrimp disease outbreak in the country (AAI, 2002). The many uses of the coastal zone include artisanal and commercial fisheries; aquaculture; agriculture; human settlements; harbours, ports and navigation; recreation and tourism; and mining industries. Such multiple uses have given rise to conflicts over resource use. Attracted by the success of shrimp farming, people started converting the traditional pokkali rice fields into prawn farms which resulted in frequent disputes between agriculture and prawn farmers and since all these activities fall in the CRZ, the Supreme Court of India proclaimed a land mark judgment that no aquaculture practices should be carried out within CRZ other than the traditional or improved traditional practices (Supreme Court Writ Petition (Civil) No 561 of 1994) which restricts the conduct of semi-intensive and intensive prawn or fish farming in the CRZ area. Consequently, the farmers who had engaged in this practice had to suffer huge economic losses. However, Kerala region was not immediately affected, as many prawn farms were traditional ones. But this judgement has restricted further expansion of these farms which could have given better returns (Ramachandran et al. 2005). A survey by the aquaculture sector found that about 5% of the shrimp aquaculture farms in India have been constructed in former mangrove area. However, with the strict enforcement of CRZ, since 1996, backed by the Supreme Court verdict, further reclamation of backwaters has been stopped. Following the verdict of the Supreme Court, the Aquaculture Authority was set up in 1996, with powers to issue licenses and guidelines and the shrimp farming sector started gaining momentum. Kerala state, having a coastline of 560 km. has about 6250 sq.km of brackish water area including marshes, backwaters, mangroves, inter and sub-tidal zones. Coastal zone in Kerala is the most densely populated area in the state.

2.1.3 Main trends in shrimp aquaculture development

Before the 1970s, small-scale aquaculture farmers produced shrimp for the domestic market. However, since the 1980s, shrimp aquaculture has been increasingly promoted by governments as a major source of foreign currency earnings. Shrimp farms expanded rapidly in Indonesia, Philippines and Thailand and other South East Asian countries. During the 1990s, the development of shrimp aquaculture became increasingly driven by public-private investments aimed particularly at generating earnings from export of the shrimp. Apparent early successes in shrimp aquaculture development encouraged national policy makers and international agencies to invest in the industry. The ADB and the World Bank (WB) have supported shrimp aquaculture development projects in Bangladesh, China, Indonesia, Malaysia, the Philippines and Thailand. Japan, the United States and the European Union (EU), have also added to bilateral development support packages. Some multinationals like 'Charoen Pokphand' is involved in the full cycle of production, i.e, from inputs to overseas marketing (Mulekom et al. 2006).

2.1.4 Aquaculture and the Coastal Zone

Since time immemorial, the coastal zone has been a center of human activity because of its high biological productivity and easy accessibility. Close to half of the world's population resides within 100km of the coastline. The wide variety of goods and services provided by mangroves, seagrasses, coral reefs and other coastal ecosystems include the production of aquatic plants and animals used for food, medicines, construction and other human needs; recycling of nutrients and filtration of pollutants; control of flooding and soil erosion; and protection from typhoons, storm surges and tsunamis. The global value of coastal ecosystems has been estimated at US$12.57 trillion/year and those of mangrove forests, together with tidal marshes at US$1.65 trillion/year (Primavera 2006).

Aquaculture has become large enough to have significant impacts on the environment and natural resources, and a number of concerns have been expressed by both environmental activists and scientists.

2.1.4.1 Contribution to domestic food security and employment

Aquaculture contributes significantly to the world food supply, providing around 30% of fisheries production. Still, many researchers express serious doubts about contribution of aquaculture towards domestic food security and employment. According to (Mulekom et al. 2006), even when aquaculture is expected to increase both employment and the supply for domestic food consumption, it makes little contribution to local food security since most shrimps are exported. Also, shrimp aquaculture itself already expends more food than it produces, i.e, for every ton of shrimp, at least 1.5–2.6 tons feed are needed. The employment generation is limited to 1–5 persons/ha (from very extensive to very intensive aquaculture) whereas subsistence employment in 1 ha of mangrove or coastal wetland can range between 10 and 40 persons much higher than that generated by the same area of a shrimp farm. Moreover, outsiders are usually employed by shrimp farm operations and the loss of access to coastal habitats as a result of this is estimated to contribute substantially to the unemployment of millions of individuals(Mulekom et al. 2006).

2.1.4.2 Disease as a constraint to aquaculture

The aquaculture industry has been faced with many problems and diseases caused by viruses, bacteria, fungi, parasites and other undiagnosed and emerging pathogens. The lifespan of most intensive shrimp ponds seldom exceeds 5–10 years in many countries, due to self-pollution and disease problems. The outbreaks of viral and bacterial diseases have caused devastating economic losses, e.g. US$750 million in 1993 in China and US$210 million in 1995–1996 in India. The Quarterly Aquatic Animal Disease Reporting System (QAAD) in the Asia-Pacific, currently lists 32 diseases. These are transboundary aquatic animal pathogens/diseases (TAAPs/TAADs), that are highly contagious or transmissible, having the potential for very rapid spread irrespective of national borders and causing serious socio-economic and possibly health consequences. Disease is a primary constraint to the culture of many aquatic species, impeding both economic and social development in many countries. Disease is a result of the complex interaction between the host, the pathogen and the environment and it spreads from either cultured fish to wild fish or vice-versa. Interactions between wild and cultured fish populations are an important concern for both aquaculturists and natural resource conservators. WSSV remains an important pathogen of farmed *Penaeus monodon* and has now been recovered from wild penaeid shrimps. The cultured fish can be a source of major disease transfer to wild populations, a risk that the aquaculture industry carries. The KHV infection which initially spread from a cultured ornamental fish (koi carp) to cultured foodfish (common carp) and then into wild populations of carp is a good example. The major mode of transfer of WSSV is through the movement of infected live animals, PL and broodstock. A second important shrimp disease, Taura syndrome (TS), caused by the Taura syndrome virus (TSV) which was previously reported only from the Western Hemisphere is now becoming widespread in Asia as reported from Indonesia in 2002. The origin of the WSSV pandemic has been traced to the import into Japan of infected hatchery produced P. japonicus from Chinese hatcheries in 1993. Since then, it has spread to China, Taipei, Korea, India, the Philippines and even tropical America. In recent years, viruses, notably the WSSV and Yellowhead Virus (YHV) have caused catastrophic multimillion dollar crop losses in shrimp farms across Asia. In the Philippines, cultured P. monodon showed 100% incidence of the infectious hypodermal and hematopoietic necrosis virus (IHHNV) compared to a mean of only 51% in four wild tiger shrimp populations(Kautsky et al. 2000).

2.1.4.3 Environmental impacts

Kautsky et al. (2000) opines that aquaculture is basically a natural ecological process, although in intensive shrimp farming it reaches industrial proportions. The boom-and-bust pattern of this industry is further indicated by the fact that 70% of previously productive ponds has been abandoned in Thailand and many other countries.

2.1.4.4 Mangrove conversion

Mangrove conversion to shrimp ponds is the single major factor that has contributed to the negative press received by aquaculture. Globally, more than a third of mangrove forests have disappeared in the last two decades, and shrimp culture is the major human activity accounting for 35% of such decline. Southeast Asia has 35% of the world's 18 million ha of mangrove forests, but has also suffered from the highest rates of mangrove loss. The recent tsunami in Southeast Asia has also highlighted the critical role and immeasurable value of mangroves as protection for coastal communities.

2.1.4.5 Collection of wild seed and broodstock, loss of bycatch

Many aquaculture farms in Asia stock wild-caught juveniles rather than hatchery-reared post-larvae derived from wild spawners or broodstock. Collection of such 'seedstock' and adult *P.monodon* to provide eggs for hatcheries, or for broodstock. can have major consequences for wild fisheries in terms of high rates of bycatch. There is high demand for wild adult P. monodon, it is reported that 220,000 broodstock were required for 185 hatcheries in India in the late 1990s, undoubtedly resulting in the loss of substantial numbers of fish and invertebrates through bycatch.

2.1.4.6 Use of antibiotics and chemicals

Excessive and unwanted use of chemicals used in shrimp culture can result in toxicity to non-target populations (cultured species, human consumers, and wild biota), development of antibiotic resistance, and accumulation of residues. Risk to humans stems from the persistence of chemicals in edible tissues. The direct effects of the chemotherapeutants and antibiotics on humans constitute a public health concern. The collapse of the 1988 shrimp crop in Taiwan was due, among other factors, said to be due to the indiscriminate use of antibiotics. A majority of Thai shrimp farmers were reported to (74%) have used antibiotics, mostly on a prophylactic basis.

2.1.4.7 Aquaculture wastes and coastal pollution

As shrimp biomass and feed inputs grow, the water quality in intensive ponds deteriorates over the cropping cycle. Total nitrogen (N) and phosphorus (P), nitrite, silicate, orthophosphate, dissolved oxygen, and biological oxygen demand increase and water visibility decrease in intensive ponds throughout the grow-out period. Sediment is the major sink accounting for 31% of N output, 84% of P, 63% of organic matter and 93% of solids, and accumulates in intensive shrimp ponds at the rate of 185–199 mt/ha/cycle.

2.1.4.8 Salinization of soil and water

Pumping large volumes of underground water to achieve brackish water salinity in the 1980s to mid-1990s led to the lowering of groundwater levels, emptying of aquifers, land subsidence and salinization of adjacent land and waterways in Taiwan and Southeast Asia. The development of low salinity shrimp farming in Thailand paved the way for industry expansion into rice paddies and other inland sites, though the inland shrimp farming was banned in 1998.

2.1.4.9 Dependence on fish meal and fish oil

The promotion of aquaculture development has been based on the premise that it can compensate for the shortfall in food production due to declining wild fisheries. Of the total 1997 capture fisheries landings of 96mmt (excluding by catch), 66 mmt was directly consumed by humans and 30 mmt was used in fish meal and fish oil production. Of the total 1997 aquaculture production of 37 mmt, 10 mmt of fish was used for aquafeeds ultimately giving a net aquaculture production of 27 mmt. The proportion of fish meal in aquaculture feeds is much higher than in poultry and livestock feeds, with one kilogram of carnivorous fish requiring up to 5 kg of wild fish. The increasing demand for fish meal, fish oil and raw ('trash') fish is fastest in aquaculture, growing from 10% in 1988 to 33% in 1997 and 65–68% in 2002. Only production of filter-feeding molluscs, and herbivorous and omnivorous fish that directly consume microalgae and seaweeds, represents a net contribution of aquaculture to global fish supplies.

2.2 Best Management Practices (BMP) in Aquaculture

Several researchers have pointed out the importance of implementing BMPs in aquaculture (Standley 2000, Boyd 2003, Reantaso et al, 2005, Subasinghe 2005, Primavera 2006, Mulekom et al. 2006). Subasinghe (2005) has conducted a series of studies and trials to control diseases affecting the small-scale shrimp farming sector in southern India and emphasizes the significant benefit of close collaboration with farmers, capacity and awareness building among them and the importance of understanding the risk factors and implementing BMP in shrimp farming. Simple BMPs for pond bottom preparation, water management prior to stocking, seed selection and stocking and post stocking management were developed and used during the study. Primavera (2006) opines that responsible aquaculture can be promoted by government regulation, market mechanisms and self-regulation in the form of codes of conduct and best management practices.

2.2.1 Water quality managenment

Mariculture requires a high volume of brackish water. The interaction of shrimp mariculture with the natural environment is a matter of serious concern among industry members and environmental organizations.

Stanley (2000) recommends reduced water exchange as one of the best management practices to reduce water pollution problems associated with shrimp mariculture and suggests that implementation of BMPs is the solution for public water pollution. Compared to other animal operations mariculture operations use more water to produce a metric ton of meat. A study by the Environmental Defense Fund estimates that intensively-farmed shrimp require 29 000–43 000 m3 per ton of fish produced in aerated systems. Semi-intensive operations use less water at an estimated 11 000–21 430 m3 per ton of shrimp produced. Mariculture water use often creates various inter and intra-industry social problems because it affects downstream artisanal fishing operations, increases risk of disease transfer across farms, aquaculture's high water use may extend the distribution of snail habitat and possibly diseases such as schistosomiasis, human consumers of fish products may be indirectly affected by chemical residues derived from pond waste and unsightly and foul-smelling estuary water may reduce the enjoyment of potential recreational users of an estuary (Stanley 2000).

2.2.2 The Mariculturist's Perspective

Stanley (2000) presents the mariculturist's perspective regarding water use as that 1)they are victims of adverse externalities from other users of a waterway, 2)their contribution to water quality is a positive externality, if waters flushed out of shrimp ponds are cleaner than the influent waters, 3)even though aquaculture tends to produce a higher volume of effluents than other activities, it is of lower concentration, 4)since monitoring each farm's water canal is impossible the effort of an individual farm would remain unnoticed, 5)the dispersal path of shrimp farm waste has not been fully investigated, confusion still exists as to the critical levels of waste from individual farms or whether farms as a group threaten ecosystem recovery by damaging ambient levels beyond a safe minimum standard and 6)no information is available regarding the carrying capacity of the receiving waters.

2.2.3 The barriers to the adoption of BMPs

The difficulty in quantifying and valuing medium-term benefits of BMPs, inability of scientists and policymakers to quantify the longer run private and social benefits of best management practices, the voluntary approach with little role for governments, the difficulty in measuring effluents and overcoming the perceptions of the farmers etc. are the barriers to the adoption of BMPs (Standley 2000). Perceived fixed costs and production uncertainties are real obstacles to BMP adoption according to Boyd (2003) and suggests the following 'structural BMPs'such as on farm intake or effluent treatment plants, sludge removal and co-production schemes as well as the three 'managerial BMPs' such as improved feed and fertilizer management, lower stocking rates and reduced water exchange or even closed recycling systems to reduce mariculture water effluents while maintaining farm profitability. According to him, no financial analyses to date have demonstrated an overwhelming economic gain through the adoption of BMPs, these analyses when done often overlook important medium-term benefits of BMPs. The farmers nature of overestimating these short-run pond productivity losses due to the adoption of BMPs, inadequate risk-sharing mechanisms etc.magnify this problem. The benefits pointed out are additional cost-savings through reduced feeding and soil fertilization costs, lowered risk of cross-farm contamination, adoption of BMPs may result in making the public water cleaner etc.

2.2.4 Regulations for Aquacultural Effluents

It has been reported that no more than 25% to 30% of the nitrogen and phosphorus applied to ponds in fertilizers and feeds is recovered in fish or shrimp at harvest. Estimates of total waste production in semi-intensive mariculture operations vary widely. Effluent loading studies on semi-intensive Honduran shrimp operations revealed the presence of approximately 849 kg of carbon, 35 kg of nitrogen and 12 kg of phosphorus for 1000 kg of live shrimp produced. Higher loadings of 455 kg of nitrogen, 238 kg of phosphorus and 196 000 kg of total suspended solids per hectare have been observed even in low-density operations in Asia. The common implications of these loadings include, hypernutrification of adjacent estuaries with pond effluents, destruction of estuarine biota through pumping, increased sedimentation due to organic matter, and reduced dissolved oxygen in receiving waters.

Many nations have made aquaculture effluent regulations. Effluent regulations mandated by governments often require compliance with water quality standards containing numerical criteria. Alternatively, regulations sometimes are based mainly on mandated use of environmentally responsible practices. A water quality standard might contain the following water quality restrictions: pH, 6 to 9; dissolved oxygen, 5 mg/l or more; 5-day biochemical oxygen demand (BOD5), 30 mg/l or less; total suspended solids, 50 mg/l or less. Sometimes, the standard also may place a restriction on discharge volume. There may be qualitative criteria in standards, such as no discernable odor, no foam, or no visible plume at the outfall. Sometimes, discharge permits only require the application of specific practices called best management practices while others may contain both water quality standards and BMPs (Boyd 2003).

2.2.5 Effluent standards and permits

The worldwide concern over environmental issues in aquaculture, has forced many developing nations to prepare codes of conduct and aquaculture effluent regulations. Consequently, our country also did so. The standards that have been required for farm effluents apparently are the same ones required for fish processing operations. Initial and target water quality standards for shrimp farm effluents recommended by the Global Aquaculture Alliance (GAA).

Table 2.1 Standards for Farm Effluents

Variable	**Initial standard**	**Target standard**
pH (standard units)	6.0– 9.5	6.0–9.0
Total suspended solids (mg/l)	100 or less	50 or less
Total phosphorus (mg/l)	0.5 or less	0.3 or less
Total ammonia nitrogen (mg/l)	5 or less	3 or less
5-Day biochemical oxygen demand (mg/l)	50 or less	30 or less
Dissolved oxygen (mg/l)	4 or more	5 or more

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Table 2.2 Guidelines for wastewater from coastal aquaculture farms in India

Parameter	Final Discharge Point	
	Coastal Waters	Creeks/estuaries
pH (standard units)	6.0– 8.5	6.0–8.5
Total suspended solids (mg/l)	100	100
Dissolved phosphate (mg/l) as P	0.4	0.2
Total nitrogen (mg/l) as N	2.0	2.0
5-Day biochemical oxygen demand (mg/l)	50 or less	30 or less
Dissolved oxygen (mg/l)	Not less than 3	Not less than 3
Free ammonia (as NH_3-N) mg/l	1.0	0.5
Chemical oxygen demand COD(mg/l)	100	75

Guidelines for ETS in shrimp farms by Aquaculture Authority, Govt. of India. Application of traditional effluent treatment methods to meet effluent standards, as done for point source pollution, will be difficult or impossible for shrimp aquaculture and many involved in aquaculture believe that application of BMPs would be the best way to improve the quality and reduce the volume of pond effluents. During recent years, Several organizations have suggested systems of BMPs for making pond aquaculture more environmentally responsible. The GAA and Aquaculture Certification Council (ACC) have certification program for shrimp aquaculture, in which shrimp will be certified as being produced according to specific standards. Some governments, such as Thailand, have succeeded in enticing small-scale shrimp and fish farmers to produce certified(GAP) aquaculture products for export. The ACC already has a certification program based primarily on compliance with BMPs while Producer associations, such as the GAA, are developing BMPs through codes of conduct and eco-labelling efforts. Some organizations allow producers to adopt environment management systems (EMS) based on record-keeping and BMPs and be certified as following the EMS.

2.2.6 The role of policy in adoption of BMPs

Neori et al. oints out that Salmon farms in Norway are legislated, regulated and licensed on siting, disease control, use of therapeutants, interaction with other species, waste discharges and feed quotas. S!anchez and Muir (2003) opines that low level of involvement of government as the main aquaculture technology facilitator has influenced negatively the appreciation of fishermen towards the link between technology and potential benefits and improvement of livelihoods. Ramachandran et al, 2005 points out that consequent on the Supreme Court judgment that no aquaculture practices should be carried out within CRZ other than the traditional or improved traditional practices, (Supreme Court Writ Petition (Civil) No 561 of 1994) the farmers who had engaged in semi-intensive and intensive prawn or fish farming in the CRZ area, though few in number, had to suffer huge economic losses. Also, this judgement has restricted further expansion of these farms which could have given better returns. According to Ababouch (2006), the implementation of the HACCP approach requires an enabling policy and regulatory environment at national and international levels with clearly defined rules and standards, establishment of appropriate food control systems and programs at national and local levels, and provision of appropriate training and capacity building. Caswell (2006) discusses the potential for certification and labeling as a mechanism for reducing marine-based public health risk which requires strict control of several attributes of seafood products, often including location and conditions of catch or aquaculture, processing, and handling throughout the supply chain. It requires an evaluation of how labeling or certification schemes interact with regulatory programs, such as mandatory HACCP systems, that set the safety floor in markets for seafood. Standley (2000) points out that certification is necessary as otherwise consumers will find it difficult to visually distinguishing which shrimp are farmed with BMP and hopes demand-side interventions (ecolabelling) could give farmers a price premium for sustainable shrimp farming and increase the likelihood of voluntary adoption.

According to Primavera (2006), market mechanisms like eco-labelling can command premium prices from generally affluent and environmentally aware consumers. There should be joint certification of such products by government representatives and independent third parties, and regular monitoring. Mulekom et al. (2006) suggests that if developed countries want shrimp, they should pay the full cost and not be allowed to import them at "bargain" prices while "external" production costs are shouldered by those who do not have the money, or do not benefit from the export earnings and states that the internalization of obvious external costs will dramatically change the picture from apparent profit to huge loss. The Code of Conduct (CoC) developed by FAO, even though adopted by a majority of countries, is reported as facing legal and therefore binding application. Thailand and the GAA each have one. Mulekom et al. (2006) argues that social impacts and human rights abuses associated with fisheries and aquaculture activities, role of the private sector, public and social accountability of corporations, and the so called "chain responsibility" etc. also should be addressed in such codes.

2.2.7 National Certification Programmes

Importers are demanding certified products which are farmed under Good Aquacultural Practices (GAP). FAO/NACA are playing a very constructive role in laying down international standards of certification (Anon 2008a). Several countries including Asian countries have come out with their own schemes for aquaculture certification. Thailand is one of the leaders in this area and has established the GAP, CoC and since recently, the Thai organic aquaculture program. Malaysia has its own voluntary aquaculture farm certification scheme which goes by the malay acronym "SPLAM". Bangladesh has its very own "Shrimp seal of quality" (SSOQ) program, a national scheme to certify farmed shrimp. In Vietnam, there are the "Safe Shrimp' scheme developed and implemented on a pilot scale by the national Fisheries Quality Assurance Veterinary directorate (Natiqaved). China has a well established aquaculture certification program, which includes the non-hazard food, Green food and Organic food certification program, which have different criteria and standards. While India does not have any certification scheme as such it has established the national centre for Sustainable aquaculture which extends technical assistance for achieving sustainable aquaculture and may be the precursor of an aquaculture certification scheme in the future (Anon 2008b). 95% of the farmed products in the country are contributed by small scale farmers who can not afford to defray the cost of certification (Anon 2008a).

2.3 Aquaculture Legislation

Reantaso et al. (2005) gives a good account of the International, Regional and national instruments and arrangements for maintaining aquatic animal health management.

2.3.1 International

A large number of producer associations, governmental fishery agencies, international development organizations, environmental non-government organizations (NGOs), and others have formulated CoC. Most aquaculture codes reference the CoC for Responsible Fisheries presented by the FAO of the United Nations.

2.3.1.1 The FAO Code of Conduct for Responsible Fisheries

The United Nations Convention on the Law of the Sea (UNCLOS), adopted in 1982 and in force since 1994, gives coastal States rights and responsibilities for the management and use of fishery resources within their EEZs, which encompass some 90 percent of the world's marine fisheries potential. The problems still persisted in the world's fisheries, forced FAO to develop new approaches to fisheries management and thus the CoC for responsible fisheries was developed by FAO in 1995. The Code has a total of 12 articles and two annexes. Of these, articles 9 and 10 deals with Aquaculture Development and Integration of Fisheries into Coastal Area Management respectively.

2.3.1.2 International Arrangements

India is a member of:

- World Trade Organization (WTO)
- South Asian Association for Regional Cooperation (SAARC)
- Network of Aquaculture Centres in Asia and the Pacific (NACA).

India is a party to the Convention on Biological Diversity (CBD) and has signed the Biosafety Protocol. India is also a party to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (FIGIS 2006).

2.3.1.3 International codes

In order to minimize the risks of pathogens or diseases associated with aquatic animal movements, there are a number of existing global instruments, agreements, codes of practice and guidelines; either voluntary or obligatory. OIE's Aquatic Animal Health Code (OIE, 2003a); the Code of Practice on the Introductions and Transfers of Marine Organisms of the International Council for the Exploration of the Seas (ICES) and the Codes of Practice and Manual of Procedures for Consideration of Introductions and

Transfers of Marine and Freshwater Organisms of the European Inland Fisheries Advisory Commission (EIFAC). There are also relevant articles included in the Code of Conduct for Responsible Fisheries (CCRF) of the FAO of the United Nations (FAO, 1995), the CBD, 1992 and the Sanitary and Phyto-sanitary (SPS) Agreement of the WTO.

2.3.2 Regional guidelines

Some of the provisions in the current international protocols are not always practically applicable to the diseases of concern to the Asian region and also because many countries in the Asian region share common social, economic, industrial, environmental, biological and geographical characteristics, a regionally adopted health management programme is considered a practical approach. Thus the Asia Regional Technical Guidelines on Health Management for the Responsible Movement of Live Aquatic Animals was based on a set of guiding principles developed through a regional project of FAO and implemented by the NACA.

2.3.2.1 Surveillance and reporting

The Asia-Pacific region is unique in that a quarterly aquatic animal disease reporting system has been established since mid-1998 by NACA and FAO in cooperation with OIE. This is useful for the countries which cannot afford to maintain costly investments with respect to implementing surveillance and disease zoning programs.

2.3.3 National

National strategies on aquatic animal health management contain the action plans of government based on national needs for the implementation of the Asia Regional Technical Guidelines. Asian governments implement the Technical Guidelines at the national level through the National Strategy framework.

According to the Constitution, the state legislatures have the power to make laws and regulations with respect to a number of subject-matters, including fisheries. At the central level, there are several key laws and regulations relevant to aquaculture which include the century-old Indian Fisheries Act (1897), which penalizes the killing of fish by poisoning water and by using explosives, and the Environment (Protection) Act (1986), being an umbrella act containing provisions for all environment related issues, the Water (Prevention and Control of Pollution) Act (1974) , the Wild Life Protection Act (1972) and the Coastal Regulation Zone Notification 1991 as amended in 1994, 1997 and 1998.

On 11 December 1996, the Indian Supreme Court handed out an historic decision with major implications for the aquaculture sector in a case regarding the setting up of shrimp farms in coastal areas. The Supreme Court - among other things - prohibited the construction/set up of shrimp culture ponds within the Coastal Regulation Zone and within 1000 meters of Chilka Lake and Pulika Lake, except traditional and improved traditional types of ponds. It also ruled that an authority should be constituted. The Aquaculture Authority was notified on 6th February 1997 as per the Supreme Court ruling to protect the ecologically fragile coastal areas, sea shore, water front and other coastal areas and specially to deal with the situation created by the shrimp culture industry in the coastal states/union territories and is functioning under the administrative control of the Ministry of Agriculture.

2.3.3.1 Guidelines and Codes of conduct

The Ministry of Agriculture has issued Guidelines for Sustainable Development and Management of Brackish Water Aquaculture (1995). The overall purpose of the Guidelines is to assist in formulating appropriate shrimp farming management practices and adopting measures for mitigating the environmental impact for management of shrimp pond wastes and utilisation of land/water resources in a judicious manner. They recommend States to identify lands that are fit for aquaculture and to discourage the conversion of agriculture land for aquaculture. The Guidelines also recognize the importance of wastewater treatment and prescribe standards for the treatment of wastewater discharged from aquaculture systems, hatcheries, feed mills and processing plants.

The introduction of imported shrimp seed should be prohibited since it may bring with it a number of problems including diseases, disease producing pathogens etc. In addition, the Guidelines provide recommendations on the use of chemicals, fertilizers, pesticides, chemotherapeutants and antibiotics/drugs, and recognize the importance of Feed quality and its management. The Aquaculture Authority has formulated Guidelines for Adopting Improved Technology for Increasing Production and Productivity in Shrimp Farming, Effluent Treatment System in Shrimp Farms and Application of the Precautionary Principle and Polluter Pays Principle in Shrimp Farming.

2.3.3.2 Authorization system

The Aquaculture Authority has constituted State Level Committees (SLCs) and District Level Committees (DLCs). Applications submitted by farmers are received by the DLCs. After verification of the information and field level inspections, wherever necessary, the applications are forwarded to the SLCs for consideration. After recommendation of the SLC, the applications are forwarded to the Aquaculture Authority for approval.

2.3.3.3 Environmental Impact Assessment (EIA)

The Guidelines for Sustainable Development and Management of Brackish Water Aquaculture (1995), recommend to carry out a site selection process which includes proper environmental impact assessment for units above 40 ha and incorporate an Environmental Monitoring Plan and an Environmental Management Plan under the control of State Pollution Control Boards.

2.3.3.4 Operation

The Water (Prevention and Control of Pollution) Act (1974, as amended) provides for the prevention and control of water pollution, for the maintenance or restoration of the wholesomeness of water, and for the establishment of (central and state) Pollution Control Boards. The Aquaculture Authority Guidelines on the need for Effluent Treatment System (ETS) in shrimp farms state that all shrimp farms of 5 ha water spread area and above located within the CRZ, and 10 ha water spread area and above located outside the CRZ, should set up an ETS or effluent treatment ponds/facilities and a common ETS for clusters of shrimp farms, where each farm is less than 5 ha in size.

2.3.3.5 Fish movement, Disease control, Drugs and Feed

There is no specific legislation on fish movement, disease control within aquaculture facilities and to control the use of chemicals and drugs in aquaculture. Relevant to aquaculture may be the Wildlife (Protection) Act, 1972, The Prevention of Cruelty to Animals Act, (1960) and Order No 722 (E) (2002) which includes a list of antibiotics and other pharmacologically active substances that are prohibited in the culture of, or in any hatchery for producing the juveniles or larvae or nauplii, respectively. The Marine Products Export Development Authority (MPEDA,2002) has published standards for shrimp feed and seed.

2.3.3.6 Food Safety

The Export of Fresh, Frozen and Processed Fish and Fishery Products (Quality Control and Inspection and Monitoring) Rules (1995) contain a definition of "aquaculture products" and state that these products must be treated under proper conditions of hygiene. They must not have been soiled with earth, slime of faeces or otherwise contaminated. If not processed immediately after having been pre-processed, they must have been chilled. The Rules also contain provisions on the sanitary certification of aquaculture products. The Food Safety Bill passed by the Indian Parliament recently, has also incorporated the need for pre requisite programmes into the food businesses operating in our country.

2.3.4 Fisheries management

2.3.4.1 Community-based Coastal Resources Management (CB-CRM)

According to Mulekom et al. (2006), CB-CRM is a feasible alternative to many dilemmas facing Southeast Asian governments. CB-CRM entails development of decentralized management systems wherein fishers and coastal communities take active roles as decision makers and implementers of management. Primavera (2006) is of the opinion that community participation in coastal zone management is essential and coastal zones should be delineated for fisheries, aquaculture, tourism and other uses through the process of integrated coastal zone management (ICZM). Allocation of activities to locations should be based on the carrying or assimilative capacity of the environment for a given use, protection of community resources, rehabilitation of degraded habitats, stakeholder needs and mechanisms for conflict resolution.

2.3.4.2 Sustainability and Responsible Aquaculture

Sustainability requires improvements in farm management, especially with regard to feed, water, effluents and diseases; focus on native and low trophic level species, and integration with agriculture and silviculture, in particular mangroves. Many researchers believe that sustainability can be achieved through responsible aquaculture which can be promoted by government regulation, market mechanisms and self-regulation in the form of CoC and BMPs. Many reports suggest that economic incentives and penalties and credits for effluent disposal, groundwater abstraction, chemical use, etc., may be more effective than regulatory approaches in inducing behavioral changes towards the environment and generating revenues to finance environmental policy programs. Green taxes (based on the Polluter Pays principle) can mitigate the environmental and socioeconomic damage of shrimp farms by correcting water quality problems, financing alternative water supplies in salt-contaminated areas, rehabilitating mangroves and other damaged landscapes, and compensating local populations for the loss in livelihoods (Primavera 2006).

Organic food produced avoiding the use of chemical additives, pesticides, antibiotics etc. and giving due consideration to animal welfare and sustainability is also making inroads into aquaculture which has often been blamed for its overdependence on fish meal. The brackish water area available in India including the existing traditional shrimp filtration fields located in West Bengal (46100 ha) and Kerala (10700 ha) can be easily adapted for organic aquaculture and a move in this direction has already been started by MPEDA in collaboration with Swiss Import Promotion Program (SIPPO) (Anon 2007). The seafood sector also contributes to the production of green house gases during fishing, processing, storage and distribution. The present Carbon Foot Print (CFP) move for the requirement to label seafood with CFP information focuses heavily on green house emissions during seafood transportation and in aquaculture, the feed component apparently accounts for almost 80% CFP(Anon 2008a).

2.4 Hatcheries

2.4.1 Introduction

The rapid development of shrimp farming in our country is also due to the setting up of a large number of modern shrimp hatcheries. Most of these hatcheries have state-of-the-art facilities for producing healthy and disease free post larvae. *Penaeus monodon* is the most predominant cultured species in India. There are 260 shrimp hatcheries in operation in the country with a total annual production capacity of 10.8billion shrimp seed (PL20). These hatcheries are mostly located in the east coast states, with the maximum number 133 in Andhra Pradesh followed by 72 in Taamil nadu. Location of the large number of hatcheries on the east coast is also because of the greater availability of spawners in the Bay of Bengal as compared to the Arabian sea (AAI 2002).

Wild-caught broodstock forms the only source of shrimp seed even today. Studies indicate that about 1/4th of wild caught shrimp spawners are found to be WSSV positive. The important diseases occurring in hatcheries are viral infections, vibrio infections, bacterial necrosis, fungal diseases and protozoan fouling. Diseases are commonly transmitted either vertically from parental stocks to offspring and/ or horizontally through natural vectors. Viral disease monitoring is an area of growing concern. An early and accurate diagnosis is therefore needed to detect the virus in infected shrimp. Polymerase chain Reaction (PCR) tests are now increasingly employed for detection of WSSV in the broodstock and hatchery reared larvae. Some hatcheries have set up PCR labs. The expansion of shrimp culture in many Asian countries has been facilitated by the development of large numbers of small backyard hatcheries. In Kerala, except a very few family run hatcheries, others are small scale industries which often depend upon one or two skilled managers. The hatcheries are of Galveston style characterized by the use of highly controlled, clear treated water with controlled inputs and a high rate of water exchange. Most hatcheries use a combination of microalgae, *Artemia* nauplii and artificial feeds. The high price and non availability of broodstock force the hatchery owners rely on nauplii from other states for growing upto PL 20-25 for selling which often result in low quality PL. The stress occurred during transport of nauplii, acclimation to the hatchery conditions, stocking and rearing procedures all will influence the shrimp survival. Good quality seed will be active and appear light gray to dark brown and black in colour with a clean shell which indicates that the animal is molting frequently and growing fast. The seed is acclimatized to the salinity of the pond in the hatchery itself before being transported. Over the past few years, the quality of hatchery produced seeds have been deteriorating and disease outbreaks have become very common in hatcheries. It is in this context that the necessity for following strict quarantine measures with hygienic standards and code of practices become significant.

2.4.2 Nutrition management in Hatcheries

It is well established that the nutrient content of the feed will influence growth, survival and the amount of waste products entering the system. Feeding strategies have also been found to influence water quality and shrimp health.The costs of formulated feed and labor associated with feeding are a major component of the cost of hatchery shrimp production. Hence optimizing the feeding strategy is a prime consideration in intensive shrimp hatchery management. Lemos and Rodryguez (1998) have studied the nutritional effects on body composition, energy content and trypsin activity of *Penaeus japonicus* during early postlarval development and found that even though the early postlarval period of *P. japonicus* did not show high mortalities even at a large decrease in body reserves due to poor nutritional conditions, such malnourished conditions may possibly interfere with postlarvae survival and growth performance when moved to semi-intensive growout ponds.

Vandenberghe et al.(1998) stated that the flora associated with larvae is not very stable and is influenced by the bacterial flora of the administered food and by the environment, in their studies on the Vibrios associated with *Penaeus chinensis* larvae in Chinese shrimp Hatcheries. Lavens and Sorgeloos (2000) have studied the impact of dietary conditions on the postlarval quality of penaeid shrimp and found that incorporation of HUFA, ascorbic acid, astaxanthin and immunostimulants in the diet of *Penaeus monodon* resulted in significant increase in the overall physiological condition as well as stress resistance of the shrimp fry. They have also emphasized the role of the microflora during the hatchery rearing, the possible reduction of bacteria in the live food administered and the benefits of using probionts through the diet. Vaseeharan and Ramasamy (2003) found that when the *Vibrio*-like-bacteria increases to $2x10^2$ CFU in hatcheries, mortality of the post larvae occurs and Artemia nauplii are one of the principal agents for transmission of pathogenic *Vibrio spp.* infections in post larval P. monodon. Abraham and Palaniappan (2004) have observed that Luminous bacteria were found in the larval rearing tanks in considerable numbers and the primary source of these bacteriae, *V. harveyi* (97.30%) and *V. orientalis* (2.70%) in shrimp hatchery was the faecal matter from brood stock, possibly at the time of spawning. They also indicated that luminous bacteria could enter the shrimp hatchery by many routes which include source water, brood stock, live food, hatchery equipment and colonization on PVC water distribution pipes, tank walls, contaminated hatchery equipment other than aeration provisions and hatchery personnel. Otoshi et.al (2003) have emphasized the need to produce SPF broodstock under biosecure conditions and found that broodstock shrimp (*Litopenaeus vannamei*) can be reared in a biosecure recirculating aquaculture system while maintaining good growth and high survival. Studies by Vaseeharan et al. (2005) has revealed that antibiotic-resistant bacteria are widespread in the shrimp culture hatcheries and ponds in India and resistant bacteria were more commonly isolated from the hatchery than from the grow-out ponds. They attribute the reason for the presence of the high proportion of antibiotic-resistant *Vibrio* and *Aeromonas* in the hatcheries to the inappropriate use of antibiotics on a long-term 'prophylactic basis' in medicated feed which could also result in the rapid leaching of antibiotics into the water and sediments and point out the need for standardisation and safety of drugs used in aquaculture for protection of the environment and humans.

2.4.3 Broodstock Management

Browdy (1998) has reviewed the developments in penaeid broodstock and seed production technologies. Most nauplii for stocking marine shrimp hatcheries are still derived from wild gravid spawners collected at sea and hence wild broodstocks are facing increasing pressure. The dependence on wild stocks which determines the price, production and quality of seeds continues to be a significant bottleneck in hatchery technology. Stable supplies of high quality seed stocks are essential for the sustainable grow-out operations. In the hatchery, problems with unexplained mortality and pathogenic bacteria continue to affect the stability of production and seed quality. Even though many advances have been made in the development of technology for the captive maturation and reproduction of penaeid shrimp, it has not yet taken momentum in our state.

2.4.4 Quality criteria for shrimp larvae

Several studies have pointed out the need for a quality criteria for shrimp post larvae. A number of techniques have been developed to evaluate fry quality in *P. monodon.* These include: 1 visual observation of fry for size, size distribution, activity, pigmentation, abnormalities and morphological characteristics; 2 evaluation of the age of postlarvae e.g., rostral spines and hatchery performance for factors like survival and development rate; 3 microscopic examination of wet mounts for condition of the hepatopancreas and fouling organisms; 4 evaluation of muscle development, muscle-to-gut ratio and presence of swollen hind gut; and 5 stress tests including salinity and temperature shocks, exposure to formalin or packing and simulated shipment tests. A combination of these tests can yield a good reference for overall seed quality.

It has been documented by several authors that feeding regime has a direct bearing on the quality of PL raised. Lee (2003) has opined that formulated feeds when used as a delivery system for substances such as hormones and vaccines would be an asset to hatcheries and the quality of fish larvae is an important factor in hatchery production, but the criteria for quality determination have not yet been established. Samocha et al. (1998) have studied the effect of age on resistance to low salinity and formalin stress in early PL *of Penaeus vannamei* and found that resistance to reduced salinity and formalin increases with age. They proposed that these stress tests, which are rapid, inexpensive and simple, can be used by shrimp hatcheries as a quality control procedure. Earlier studies have pointed out that Nauplii with relatively high levels of reserves might have higher probability of survival during metamorphosis to zoea, while Racotta et al.(2004) found no relation between larval survival and biochemical composition of nauplii. However their studies using the ammonia stress test as an early criterion of larval quality, indicated that survival to the ammonia stress test in early stages such as nauplii and zoea could be used as a predictive criterion of percent survival during culture to zoea, or "metamorphosis" from nauplius to zoea and survival of zoea during culture to PL1 stage respectively and the average survival of PL1 from a salinity stress test of 18 ppt during 30 min was 64%. The significant correlation between survival from the salinity stress test at PL1 and during culture from PL1 to PL20 indicates that it can be applied to detect high performance batches. Thus, the salinity stress test might be useful either at earlier stages as a predictive quality criterion or at later stages as a final PL quality criterion. It is well known that PL tolerance to low salinity increases with age, through development of osmoregulatory capacities. Almost all researchers have used salinity near 0 ppt for stress tests for PL20 and 20 ppt for PL of 5 days old or less. The use of a low salinity stress test on advanced PL is sustained by its predictive value for performance during stocking. Studies have proved that several traits determined at PL1 such as gill area, PL size, and acylglycerides concentration and fatty acid content were linked to PL survival from salinity stress and of all these traits assessed at PL1, survival from salinity stress predicted PL survival during culture to later stages.

2.4.5 Environmental impact

The environmental impacts of the wild shrimp seed fishery as well as the possibility of environmental degradation from mass production of shrimp seed in hatcheries has been documented by several authors (Islam et al. 2004, Primavera 1998). The shrimp hatchery also is facing increasing pressure to lower its environmental impact. Because of the wild seed collection activities, not only are the natural stocks of shrimp seeds now overexploited worldwide but it has also significantly reduced stocks of other living resources. Huge mortality and loss of other species have been reported for every single P. monodon PL collected from the wild. Hatchery production of shrimp seeds started in 1980s and has been a potential alternative of wild shrimp seed. It has been estimated that 65–75% of all PL used by shrimp farms at present globally are produced in hatcheries. The shrimp fry fishery posed serious impacts on the regional biodiversity and aquatic community structure, not only by directly killing vast number of fish and shrimp species but also by reducing the food availability of other organisms such as aquatic birds, reptiles etc. linked through the food web.

Large-scale hatchery productions provide a potential source of coastal pollution and a major concern is the discharge of nutrients from shrimp hatchery into coastal waters, with the potential to contribute to increased algal blooms, oxygen depletion of bottom waters and reduced biodiversity. The wastes produced in shrimp hatcheries include left over feeds, feces, fertilizers and other chemicals, dead shrimps and algae, partially decomposed organic matters, bacteria, virus and other microflora, inorganic nutrients particularly nitrogen and phosphorus. Antibiotic resistant bacteria, MBV, hepatopancreatic parvovirus (HPV), and WSSV are commonly reported in shrimp hatcheries. Therefore, shrimp hatchery effluents are likely to have a high load of pathogenic microorganisms. Daily discharge of effluents from hatcheries with shrimp PL production ranging 10–100 million PL/month, is reported to be quantities of 50–2000 m3, respectively, depending on the size of the hatchery. Most of the hatcheries do not have facilities for monitoring chemical composition of the discharges. Most of the nutrients discharged from intensive shrimp hatcheries originate from the formulated feed. Therefore, efforts to improve feeding strategies must focus on both optimizing production and minimizing waste.

2.4.6 Norms for Registration of Hatcheries

The Coastal Aquaculture Authority Act, 2005 enacted by the Parliament in June 2005 is for regulating the activities connected with coastal aquaculture in the coastal area and for matters connected therewith. The MPEDA, Kochi is entrusted to carry out the registration of shrimp hatcheries and the objectives of the norms for registration of shrimp hatcheries are to ensure that the hatcheries are set up and function as per the Guidelines and the seed produced and distributed to the shrimp farmers is of high quality and confirms to the standards fixed for the purpose. The marine shrimp species like *Penaeus monodon, Fenneropenaeus indicus, Fenneropenaeus merguiensis, Marsupenaeus japonicas* and *Metapenaeus* spp. would be considered for registration. Hatcheries may vary from units that can produce only nauplii, nauplii to PL or combined units with all necessary facilities such as broodstock rearing, nauplii production and their rearing up to PL stages. The hatchery may also have facilities for live feed culture. Hatcheries are classified into small-scale units with a production capacity up to 10 million PL-20 per annum, medium-scale units with a production capacity above 10 million but up to 30 million PL-20 per annum and large-scale units with a production capacity of above 30 million PL-20 per annum. The registration of hatcheries is valid for a period of five years.

2.4.6.1 Hatchery facilities required

Shrimp hatcheries undertaking maturation of brood stock, production of nauplii and their rearing to post larval stages (up to PL - 20) would be required to have permanent construction with identified facilities for quarantine and holding of brood stock, spawning tanks, larval and post - larval rearing areas and nursery, facilities for live feed production, microbiology and pathology laboratories, stores and designated areas for packing, and staff amenities including accommodation, toilets and common facilities for meetings, recreation and canteen. The premises of each hatchery should be properly fenced with secured gates for movement of staff, vehicles other authorized visitors and prevention of stray animals from entering the premises. The hatcheries should also ensure that common property resources, such as beaches or sea facing areas are not fenced, as this would put the neighboring community into inconvenience. The hatcheries should also have adequate freshwater supplies for the purpose of washing, cleaning and drinking. The hatcheries should have an approachable road for easy access and adequate communication facilities such as telephone, fax and email.

2.4.6.1.1 Water purification

The sea water should be treated to remove suspended solids, dissolved nutrients and bacterial and viral pathogens and the water treatment protocol includes sedimentation, water chlorination and dechlorination, filtration with sand filter or activated carbon filters, cartridge filtration up to 1 micron size and UV filtration/ ozonisation.

2.4.6.1.2 Power supply

The hatchery should have a three - phase electrical connection, standby generators, pumps for sea water supply and air blower.

2.4.6.1.3 Manpower

The required categories of staff, their number and qualification is provided in Table 2.3 below.

Table 2.3 Required categories of staff in a hatchery

Sl.No	Category	Qualification
1	Manager	Graduate
2	Hatchery Technicians	Graduate with specialization in Fisheries/ Aquaculture
3	Laboratory Technician	-do- or Trade Certificate in Laboratory Technology
4	Hatchery Supporting staff	Higher Secondary/ SSLC
5	Laboratory Supporting	-do-

	Staff	
6	Electrician/ Pump man	Trade Certificate
7	General duty Staff	
	(Cleaner/ watchman/ cook, etc)	Minimum qualification up to Std. VIII.

Physical facilities of a hatchery includes seawater and freshwater intake systems, maturation tanks, spawning/ hatching tanks, larval rearing tanks, live feed algal culture lab, artemia hatching tanks, generators, air blower/ compressor, staff quarters, office buildings and the hatchery laboratory with equipments like PCR and its related accessories, balance, glassware, air conditioning, deep freezer, etc.

2.4.6.2 Important management norms

2.4.6.2.1 Hygiene and Sanitation Management

The hatchery should have a clean appearance and should adopt high standards of hygiene to ensure strict bio-security. The equipments and tools used in the hatchery should be made from non-toxic materials and should be cleaned and sterilized/ disinfected properly. Different sections of the hatchery such as maturation, hatching, etc should have minimum inter-connections to avoid contamination from one section to the other. The live feed section should be completely separate from the other sections. As far as possible, separate paraphernalia should be used for different tanks/ sections, etc. The movement within different sections of the hatchery should be restricted to the persons assigned to the section. Separate staff should be designated for each section of the hatchery and frequent inter-changing of staff from one section to the other should be avoided. It should also be ensured that the staff deployed possesses adequate knowledge of the task allotted to them and also the maintenance of biosecurity environment in the hatchery.

To ensure general hygiene and sanitation it must be ensured that the flooring is properly plastered and there are no holes and crevices to allow stagnation of water and growth of undesirable organisms. The flooring should also have proper slope to allow flow of water into the outlets. The hatchery should be adequately illuminated. The inlet and outlet pipes should be provided with screens and stoppers to ensure that there is no entry or escape of animals. The stoppers will also ensure that water due to backflow/ backlash does not enter the hatchery. The area where seed is packed for distribution should be free from any contamination and no unauthorized person should be allowed to enter this section. A flow chart of activities/ movements between one section to the other should be maintained and strictly followed. Entry and exit points of each section should have footbaths and other wash facilities to minimize contamination. Monitoring of the quality control parameters should be carried out on a daily basis and no relaxations should be made on biosecurity aspects of the hatchery.

2.4.6.2.2 Health Management

It is well known among aquatic animal health scientists and workers that if feed and environment in hatchery are well managed, the animals will have less stress and hence less disease infection. When disease occurs, there should be efficient measures to prevent disease outbreak to other hatcheries and natural water sources. The bio-security measures to be adopted for adoption by the hatchery manager are the following; 1) Larval health and water quality in hatchery should be regularly monitored and examined. If some symptoms of disease occur, it should be diagnosed in the laboratory, 2) PL should be nursed in as much a healthy manner as possible so that they do not carry diseases to grow-out pond, 3) The use of permissible drugs and chemicals should be discontinued sufficiently long before harvesting the larvae for stocking in grow out ponds in order to prevent drug and chemical residues being left in the body, 4) For diseases caused by poor hatchery management, good preventive measure is the best solution, 5) There should be effective measures to prevent the outbreak and spread of shrimp disease to nearby hatcheries and water sources, 6) Instructions for quick transportation of shrimp fry without application of drugs and chemicals during packing should be given to the farmers, 7) The hatcheries will ensure that no infected seed is sold or allowed to be disposed in a manner that may have an impact on the fauna and flora of the surrounding open waters.

2.4.6.2.3 Diagnostic facilities in the hatchery

It is recommended that the hatcheries should maintain the following set of equipments to perform the diagnostic functions and also ensure sound health of the animals: Autoclave, Electronic Balance, Microscope, PCR Equipment, Refrigerator, pH meter, Salinometer, Dissolved Oxygen meter, Kits for testing other nutrients etc.. Besides these, the hatchery should also maintain adequate stocks of distilled water and the required glassware and chemicals.

2.4.6.2.4 Feed and Feeding Management

Live, fresh and artificial feeds constitute the key factors for the success of hatchery and nursery operations. They also contribute to the bulk of the input costs in a hatchery. Remnant feed will generally cause deterioration of water quality in hatchery tanks. If quality feed is used with a proper feed management, it can prevent feed waste and deterioration of water quality and the hatchery effluents will not subsequently cause adverse impacts on environment and coastal ecosystem.

2.4.6.2.5 Use of Drugs and Chemicals

Some drugs and chemicals may be toxic to shrimp larvae or accumulate in their bodies, which may have some effects later in grow-out pond. If they are frequently applied without proper management, chemicals left in hatchery effluent may pollute water source and subsequently have strong impact on the coastal ecosystem. This also causes drug resistance.

2.4.6.2.6 Traceability and Record Keeping

All records pertaining to the operation of the hatchery should be maintained. The various procedures adopted in the hatchery right from the sourcing of brood stock to the sale of seeds should be properly recorded. A systematic approach to record keeping can help in effective monitoring. Ensuring traceability in the seed production phase is a pre-requisite for a standard hatchery and therefore all records/ register maintained by the hatchery will be subjected to verification during the inspections. Such arrangements should also be adequately demonstrated to ensure that the traceability programme is in place.

2.4.6.2.7 Effluent Management

The effluents discharged from the hatchery should meet the standards stipulated for the same and should be disposed of in a manner not polluting the environment. In order to treat the discharge, an effective effluent treatment system should be set up in the hatchery. The standards for the source water as well as the final discharge point for hatcheries are furnished in Table 2.4.

Table 2.4 Standards for source water and water at the final discharge point

Parameter	**Intake point**	**Discharge point**
PH	6.0-9.5	6.0-9.0
Total suspended solids (Mg/	100 or less	50 or less
litre)	0.5 or less	0.3 or less
Soluble Phosphorus (Mg /liter)	5 or less	3 or less
Total ammonia nitrogen	50 or less	30 or less
BOD (Mg/ liter)	4 or more	5 or more
Dissolved oxygen (Mg/ liter)	No discharge	No discharge
Salinity	above 800 Mg/ liter chloride in to fresh water	above 550 Mg/ liter chloride into fresh water

2.4.6.3 Seed specifications

The seed specifications are shown in Table 2.5 and the list of antibiotics and other pharmacologically active substances banned for use in aquaculture are shown in Table 2.6 respectively.

1. Seed supplied by the Hatcheries must be healthy.
2. They should survive standard stress tests conducted in the hatchery for temperature, salinity (or both) or chemicals such as formalin.
3. 3 They should not be found infected with viruses such as WSSV and MBV.
4. 4 The disease free status should be supported with PCR or other similar test report.

5. Healthy seeds should have the characteristics under naked eye and
6. Microscopic observations as detailed in table under.

Table 2.5 Seed specifications

Sl No.	Parameter	Standard
1	Colour	Light grey, brown or black.
2	Activity	Actively swimming
3	Feeding	Readily accept and eat feeds
4	Shell	Clean shell.
5	Muscle	Clear, smooth and thick, completely filling the space below the gut.
6	Gut	Full gut.
7	Muscle Gut Ratio	Tail muscle to hindgut ratio of 4:1 or more
8	Hepatopancreas	Animals without hepatopancreas should not be more than 10 % of the animals tested.
9	Rostral spines	More than five rostral spines should be observed in at least 80 % of the tested animals.
10	Body length (BL)	Above 11.0 mm.
11	Size variation	Less than 10 %.
12	Pigmentation	Chromatophores well defined and located along the mid-ventral line.
13	Appendages	Intact, without any deformity
14	MBV/ WSSV	Negative.
15	Stress test survival	Above 80 %.
16	Swollen hind gut	Less than 10 %.
17	Fouling organisms	Less than 20 %.

Table 2.6 List of antibiotics and other pharmacologically active substances banned for use in aquaculture

Chloramphenicol	Dimetridazole
Nitrofurans inlcuding: Furaltadone,	Metronidazole
Furazolidone, Furylfuramide,	Ronidazole
Nifuratel, Nifuroxime, Nifurprazine,	Ipronidazole
Nitrofurantoin, Nitrofurazone	Other nitroimidazoles
Neomycin	Clenbuterol
Nalidixic acid	Diethylstilbesterol
Sulphamethoxazole	Sulphonamide drugs (except
Aristolochia spp. and preparations thereof	approved Sulphadimethoxine,
Chloroform	sulphabromomethazine and
Chlorpromaxine	sulfaethoxypyridazine)
Colchicine	Fluoroquinolones
Dapsone	Glycopeptides

2. 5 History of Food Safety and Origin of HACCP

Many workers have reported that food safety has been of concern to humankind since the dawn of history (Bryan 1992, Motarjemi et al.1996). Motarjemi et al. (1996) pointed out that the concern about food safety which has grown in recent years due to increased incidence of foodborne diseases, increased consumer awareness of food safety, increased international trade in foodstuffs, new food processing methods, changing lifestyles, increased contamination of the environment and industrialization and mass production coupled with lack of sufficient resources and the recognition of the limitations of traditional approaches to food safety assurance, accentuated the need for a cost effective food safety assurance method, the HACCP. According to Bryan (1992), HACCP is a combination of several approaches like surveillance of foodborne diseases, surveillance of foods and food operations, surveillance of facilities and equipment used for food production, surveillance and training of the food handlers, education of the public etc. which had been used to implement the food laws., particularly, approaches like surveillance of diseases, foods and operations and education into an action-oriented program to identify and reduce foodborne disease problems. Pearson and Dutson (1995) indicated that the habitat and resource concerns, along with increased consumer awareness, the need to harmonize food standards internationally to facilitate trade and increased reliance on imported food products etc. forced the regulatory officials and legislators alike to search for new innovative control and inspection strategies to manage the public risk by incorporating the changing scientific, technical, sociological, legal and institutional realities, without a diminution of the existing food control and risk management percepts, which resulted in the birth of a more science-based approach, namely the HACCP system. The HACCP system, pronounced "Hissop" is a scientifically based protocol that may be used to deal with any type of prepared, processed or preserved food and can be applied directly to the food procurement, production and distribution process. It is interactive; food plant personnel use it to plan and establish procedures designed to prevent or eliminate food safety hazards or to reduce them to acceptable levels (Corlett 1998).

2.5.1 Evolution of Global Food Safety System

From the earliest religious edicts concerning food, innumerable ordinances, codes of practice, and laws concerning processing, handling and sale of foods have been promulgated by local, national and international bodies with the intention of protecting the public from adulterated food, fraud and foodborne illness (Bryan 1992). Sperber (2005a) has reported that the current global food safety system, under the auspices of the United Nations began in 1945 with the organisation of the FAO. The General Agreement on Tariffs and Trade (GATT) was concluded in 1947 which included provisions for countries to apply measures necessary to protect human, animal or plant life or health. The Codex Alimentarious Commission (CAC) of FAO/ World Health Organisation (WHO) was formed in 1963 to protect the health of consumers and to ensure fair practices in world trade. The SPS came into force in 1994 and the WTO was formed in 1995. The HACCP evolved from a voluntary science based system to a mandatory legislation based system and the HACCP documents on principles and application were published in 1998 (Sperber 2005a).

2.5.2 Genesis and Evolution of the HACCP System

The HACCP programs were developed in the 1960s through joint efforts of the US Army Natick Research and Development Laboratories, the National Aeronautics and Space Administration (NASA) and the Pillsbury company for ensuring the safety of foodstuffs for the US space program (Sperber 1991a). NASA, not wanting to risk the illness of an astronaut during a space mission, had very stringent microbiological acceptance criteria, in fact 100% product testing only could assure NASA that a particular packet of food was safe to consume. The Pillsbury Company encountered this dilemma in the 1960s in its attempt to fulfill several food production contracts with the US Army and NASA. It was obvious to all involved that product testing could not guarantee food safety and a much better system of food safety was searched for which resulted in the genesis of a new concept, the HACCP. The quality control system based upon end product inspections had been used in manufacturing industries for decades before the HACCP concept was developed. Serious food safety incidents which occurred in the food processing industry after World War 11, like Salmonella contamination of dried eggs and dairy products, *Clostridium botulinum* growth or presence in canned foods etc. aroused serious food safety concerns worldwide. The limitations of QC systems to assure food safety soon became obvious and consequently, HACCP was developed and accepted as a proactive alternative to end point testing. Unlike QC systems, HACCP is a preventive system in which food safety can be designed into the product and the process by which it is produced. It is a system of product design and process control. The HACCP system of food safety is very effective at controlling identified hazards and most importantly, it does not rely upon product testing to assure food safety (Sperber 2005b). Ababouch (2000) reported that there was worldwide evaluation and reorganization of food inspection and control systems geared towards improving efficiencies, rationalizing human resources and introducing risk analysis-based approaches. Many countries have undertaken a comprehensive evaluation and reorganization of their food inspection and control systems in order to improve efficiency and harmonize approaches. This evaluation of food control systems has resulted in the convergence towards the necessity to implement a preventative approach based on the HACCP principles and away from the traditional approach that relied heavily on end-product sampling and inspection. Ropkins and Beck (2000) reported the NASA, the United States Army Laboratories and the United States Air force Space Laboratory project Group in a collaborative research program concluded that conventional end point food testing could not effectively ensure food safety because of the reasons: Significant proportions of a foodstuff have to be subsampled for analysis to ensure representivity, food safety is not ensured with regard to tested hazards, current food safety testing procedures are likely to be expensive, time-consuming, difficult to interpret and destructive, control of hazards is reactive, responsibility for food safety is focused upon a relatively small component of the work forces quality assurance and control personnel and food safety is only assured at the point of testing.

The HACCP has been in a constant state of evolution since its inception in 1972, when the Pillsbury company developed the first system and subsequently published the first HACCP text in 1973, *Food Safety Through the Hazard Analysis critical Control point system* (Corlett 1998). The Pillsbury Company in the US started application of HACCP concept to the manufacture of its consumer food products in 1972. Since then the HACCP system began to spread through the food industry as many companies recognized the benefits of this system. The US National Academy of Sciences (NAS) recognized this trend and recommended that the US food regulatory agencies change from an inspection mode to an audit mode and the NAS recommendation led to the formation of the National Advisory Committee on Microbiological Criteria for Foods (NACMCF) in 1988 (Sperber 2005a). The NACMCF brought out a HACCP document that described HACCP principles and guidelines for implementation in 1998 and an identical one was published by the CAC Committee on Food Hygiene

(CAC/CFH) in 1998. The United States serves as the permanent chair of the CAC/CFH and so it was convenient for the two committees to collaborate to some extent in order to harmonize their HACCP documents which resulted in the development of nearly identical documents. These documents were initially published in 1992 which were then refined in 1997 (Sperber 2005a). Although HACCP documentation is available from many sources, for example, International Commission on Microbiological Specification for Foods (ICMSF), NACMCF, CAC, International Life Science Institute (ILSI); there is consistency in the approaches adopted and all recommended very similar implementation protocols, the seven basic steps of HACCP implementation often referred to as HACCP principles. The original Pillsbury HACCP procedure contained three components, viz, 1) the identification and assessment of all hazards associated with the final foodstuff ,2) the identification of the steps or stages within food production at which these hazards may be controlled, reduced or eliminated: the critical control points (CCPs), 3) the implementation of monitoring procedures at these CCPs (Ropkins and Beck 2000). However, the modern HACCP system is built upon seven principles. The emergence of modern HACCP system has been discussed (Corlett 1998, Ropkins and Beck 2000, Sperber 2005a). The NACMCF 1998 guidelines are based on NACMCF 1992 and NACMCF 1997 guidelines. The NACMCF (1992) HACCP principles are:

1. Conduct hazard analysis, considering all ingredients, processing steps, handling procedures and other activities involved in a foodstuff's production.
2. Identify CCPs in the process.
3. Establish critical limits for preventive measures associated with each identified CCP.
4. Establish monitoring procedures to determine if critical limits have been exceeded and define procedures for maintaining control.
5. Establish corrective actions to be taken when monitoring indicates that there is a deviation from an established critical limit.
6. Establish effective documentation and record keeping procedures for developed HACCP procedure.

7. Establish verification procedures for routinely assessing the effectiveness of the HACCP procedures once implemented.

NACMCF (1997) defined HACCP as "a systematic approach to the identification, evaluation and control of food safety hazards based on the seven principles". The NACMCF (1997) HACCP principles are similar to the (1992) principles, but are abbreviated.

1. Conduct a hazard analysis.
2. Determine the CCPs.
3. Establish critical limits.
4. Establish monitoring procedures.
5. Establish corrective actions.
6. Establish verification procedures.
7. Establish documentation procedures.

2.5.3 The Different Views Regarding HACCP

The term "HACCP" became known throughout the world in the late 1980's. Many HACCP practitioners opine that the views concerning the interpretation and the practical implementation of the HACCP concept were different at the beginning and these views deviated very much from the original meaning of the HACCP notions of Codex Alimentarius. At this juncture, many authors came out projecting their own views. Untermann (1999) suggested the "Zurich House of Food-Safety" as a way out of the confusing situation occurred throughout the world. However, the aspect regarding the role of HACCP as a food safety control system and an element of public food safety regulation remained unquestioned. Unnevehr and Jensen (1999) suggested that HACCP is a more economically efficient approach to food safety regulation than command and control interventions and recommend the use of HACCP as an international trade standard for processed food products. Lupin (1999) has put forward the concept of equivalence and compliance and reported that the incorporation of the seven HACCP principles into the HACCP based regulations has introduced some basic criteria and procedures regarding the assessment of equivalence and therefore of achieving and certifying compliance, when a general international procedure to establish equivalence regarding fish and fish products safety, based on the criteria of the GATT Agreements, could not be reached at. The introduction of HACCP based regulations for fish and fish products, particularly in the EUand the USA, has triggered the need for production under the HACCP system in most fish exporting countries (Lupin 1999).

2.5.3.1 HACCP in the United States

The origin and growth of HACCP in the United States has been discussed (Sperber 1991a, Pearson and Dutson 1995, Corlett 1998, Ropkins and Beck 2000, Sperber 2005a). Ropkins and Beck (2000) reported much of the early HACCP development work was conducted in the US. In the years following Pillsbury Company in the US started application of HACCP concept to the manufacture of its consumer food products in 1972, the HACCP system began to spread through the food industry as many companies recognized the benefits of this system. Consequently, the NAS recommended that the US food regulatory agencies change from an inspection mode to an audit mode (Sperber 2005a). In 1973, US Food and Drugs Administration (FDA) conducted a pilot program of random HACCP audits of low acid canned foodstuffs manufacturing sites to develop Good Manufacturing Practices (GMP) strategies for the low acid canned food industry. Although, this approach was conceptually ahead of its time, the procedures developed were criticized for focusing attention on control points that were already monitored, as opposed to identifying effective CCPs. The initial lack of interest in HACCP has been attributed to this and the failure of other early attempts at implementation (Ropkins and Beck 2000). Despite the initial lack of industrial interest in the early 1970's, the FDA continued to actively popularize and encourage the adoption of HACCP within the food manufacturing sector, throughout the 1970's and 1980's. Food industry attention to HACCP principles generally remained insignificant until they were endorsed by the WHO, FAO and the NACMCF in the 1980's (Ropkins and Beck 2000). Corlett (1998) reported that although HACCP has been around for thirty years, it has undergone rapid expansion in the US food industry, primarily as the result of regulatory adoption of the system and the regulatory use of HACCP began in 1973, with the US FDA's canned food regulations. The new regulations accelerated the process of adoption when large multinational companies began requiring their suppliers and vendors to adopt the HACCP system, in the early 1990's (Corlett, 1998). According to Sperber (2005a), the HACCP system attained its current pinnacle of success in 1992 with the publication of HACCP documents by the NACMCF and the CAC/CFH which were refined in 1997 and all these developments were entirely transparent. The three major HACCP rules promulgated by the US regulatory agencies for specific segments of the industry were meat and poultry products (1996), fish and fishery products (1997) and juices (2001). The fish and fishery products HACCP regulation (CFR 1997) published by the US Food and Drug Administration specifies the requirement for sanitation standard operating procedures (SSOP's) which largely echo the current GMPs. This rule developed by FDA is in conjunction with the Salmonella performance standards in the raw meat and poultry products developed by USDA. Salmonella performance standards are a hallmark of the Pathogen Reduction/HACCP rule for the production of meat and poultry products (CFR 1996). In the background to this rule, the USDA recognized that the safety of meat and poultry products needed to be provided by a "Farm to Table" application of control measures. The juice HACCP regulation for the production of fruit and vegetable juices (CFR 2001) was enacted to prevent foodborne illnesses associated with the consumption of commercial raw juice products. The failure of product sampling to assure food safety was the very reason that the HACCP system of food safety was developed. However, as per this rule, as little as 20ml of juice from one week's production needs to be found free of Escherichia coli to provide assurance that the entire week's production is safe for consumption. The legal requirement for HACCP compliance in US food industries changed the way HACCP was subsequently implemented in the USA. Previously, HACCP was developed and implemented on a voluntary basis under which individual companies identified their own safety requirements as a means of enhancing their market potential and improving customer satisfaction. However, under the mandatory system, the first criterion for most food companies became adherence to governmental requirements and regulations (Ropkins and Beck 2000). SSOPs were a new type of requirement in the FDA and USDA HACCP regulations. SSOPs are specific sanitation and related GMPs that must be developed in a food company to provide a solid foundation for HACCP implementation. US HACCP regulations require the development of SSOPs as well as the use of the HACCP system (Corlett, 1998).

2.5.3.2 HACCP in the European Union (EU) and other Countries

The introduction of HACCP within the EU has presented significant challenges as each of the EU member states had their own unique legal structures for food safety legislation, surveillance and assurance (Ropkins and Beck 2000). An international exchange program among UK, France, Denmark, Spain, Sweden, Portugal, Belgium, Netherlands, Ireland and Greece was established and the EU subsequently produced a series of directives for incorporation into legal systems of all member states. Three 'Vertical' directives were developed for specific food stuffs. They were for fishery products (DIR 91/493), for meat and meat based products (DIR 92/5) and for milk and dairy products (DIR 92/46). The fourth HACCP directive was a horizontal directive regarding hygiene of food stuffs (DIR 93/43) and was intended as framework for the standardisation of EU member state's food hygiene legislation. The precautionary principle of EU was adopted to allow public health authorities to make decisions regarding public health protection in the absence of complete scientific information. This principle can be invoked when reasonable grounds of an unacceptable public health risk exist and when available data are insufficient for a comprehensive risk assessment. Under such conditions, measures can be taken to protect the public health, however such measures are provisional until more complete information is available. According to Sperber (2005a), the precautionary principle of EU is not as opaque as US HACCP rules, but is rather "translucent" and all these specific HACCP rules rather than maintaining the transparency of the global HACCP documents, have clouded the waters. In Australia, the adoption and implementation of HACCP had started in the early 1980s and was much more rapid and industry driven by comparison to other countries the early interest being focused on the dairy product export industry as it represents a significant component of Australian food exports. The Australian Quarantine Inspection Service (AQIS) was implementing the HACCP control system for all food export sectors such as fruit, grain, meat, seafood and vegetables (Ropkins and Beck 2000). In Canada, food legislation falls under the federal jurisdiction of four departments: Health Canada (HC), Agriculture and Agri-food Canada (AAFC), Industry Canada (IC) and Fisheries and Oceans Canada (FOC). All four departments had been actively involved in the development of HACCP legislation and FOC introduced a mandatory quality management program (QMP) for the fish processing industry which employed HACCP principles. The UK approach to HACCP legislation is an accurate interpretation of EU directive 93/43/EEC. The food companies in UK had restructured or reorganized their activities to incorporate HACCP principles prior to this legislative requirement. In the Federal Republic of Germany, the ministry of Health developed a comprehensive legislative strategy for adoption of HACCP principles. Consequently, many German food companies already have HACCP procedures in place and a large body of academic, government and industrial HACCP documentation has been published. Despite some initial reluctance, HACCP has now become increasingly popular in developing countries. A number of limitations and problems associated with HACCP implementation in developing countries are similar to those previously identified for small and medium scale enterprises in the western world (Ropkins and Beck 2000).

2.5.3.3 Development of Food Safety and Quality Assurance Systems in India

Iyer (2007) has discussed the various stages in the development of food safety and quality assurance systems in India with particular reference to seafood exports. In India, compulsory quality control was first introduced for fish and fishery products meant for export under the export quality control and inspection Act 1963. This type of quality control relying on end-product inspection often resulted in the rejection of final products and hence a better and modified system, the in-process quality control (IPQC) system where certain controls are exercisable during different processing steps like raw material purchase, pre-processing, processing and post-processing step like storage and transportation was introduced in 1997. The IPQC system was made a mandatory requirement for all exporting units and those units were regularly monitored by Export Inspection Agency (EIA) which was further modified to the modified in-process quality control (MIPQC) system. Under the MIPQC system, the responsibility of inspection and testing of raw material, in-process material and finished product were placed on the exporter and the system required additional requirements like well equipped testing laboratory and qualified and competent technologists to supervise production. Under these two systems of quality control, the certificate for export was issued by the EIA. In the late eighties, as part of liberalization of trade, Self Certification (SC) scheme was introduced. Under this scheme, exporting units were bestowed with the responsibility of testing product quality and also the authority to issue Certificate of Export. Subsequently, in 1988, the IPQC has been renamed as Quality Control and Inspection in Approved units (QCIA) and MIPQC as IPQC after incorporating some minor changes. In order to keep abreast of the developments in quality assurance systems of food the world over, India also made drastic changes in the quality control methods and a new HACCP based system called the "Quality Assurance and Monitoring System" (QAMS) came into existence under the Export of Fresh, Frozen and Processed Fish and Fishery Products (Quality Control, Inspection and Monitoring) Rules (1995) and was founded on the existing IPQC system by incorporating the requirements of both USFDA and the EU Directive 91/493. The Food Safety Bill passed by the Indian Parliament recently, has also incorporated the need for HACCP system to be adopted by the food production and retail outlets in the country. All these developments in the quality and safety front have helped India to keep in par with the developed nations (Iyer 2007).

2.5.4 Implementation of the HACCP System

The HACCP which has become popular as a system of food safety is now well-known internationally and is being implemented in many food processing industries of the US, Europe and other countries (Wallace and Williams 2001). HACCP can be successfully implemented only when a food business realizes the need for the HACCP system, takes ownership of the system, fully understand the principles of the HACCP system and when there is commitment on the part of both management and staff. Implementation of this approach requires an enabling policy and regulatory environment at national and international levels with clearly defined rules and standards, establishment of appropriate food control systems and programs at national and local levels, and provision of appropriate training and capacity building. According to Mortimore (2001) the HACCP system that really works in practice will depend on the competency of the people who both developed it and who operate it, and the PRP, which support it. Mortimore (2001) identified four stages to the application of HACCP, such as preparation and planning, application of the 7 HACCP principles, implementation of the HACCP study output and ongoing maintenance of the HACCP system. However, the CAC recommends five preliminary stages prior to hazard analysis, for implementing HACCP. The application of the HACCP system begins with the development of HACCP plan. It is a systematic process, a sequence of twelve tasks has been described, in which after the first five steps, the seven basic principles of HACCP are included (CAC, 1997) and is illustrated in Table 2.7.

Table 2.7. Logic sequence for the application of HACCP

No.	Steps
1	Assemble HACCP Team
2	Describe Product
3	Identify Intended use
4	Construct flow diagram
5	On-site Confirmation of Flow Diagram
6	List all potential Hazards Conduct a Hazard Analysis(principle 1)
7	Determine CCPs (principle 2)
8	Establish Critical Limits for each CCP (principle 3)
9	Establish a monitoring System for each CCP (principle 4)
10	Establish corrective actions (principle 5)
11	Establish Verification Procedures (principle 6)
12	Establish Documentation and Record Keeping (principle 7)

HACCP implementation is usually a team exercise as no individual is likely to have all the practical, technical, theoretical and managerial expertise required. Typical teams might include a chemist, engineer, food technologist, microbiologist, production manager and quality assurance manager among others (Ropkins and Beck 2000). After the initial five steps are completed, the development of the HACCP plan continues with the application of HACCP principles 1 through 7. The HACCP plan is used as the blueprint for developing procedures, for training in system application in the production or food service environment, and as the reference for conducting a verification audit of the HACCP system. During an audit it is determined whether a particular process is in compliance with the HACCP plan, and whether the HACCP plan needs modification and validation. The USDA meat and poultry regulation defined the HACCP system as "the HACCP plan in operation, including theHACCP plan itself" (Corlett, 1998). The sequence of events leading to the establishment of HACCP in a food company is shown in Table 2.8.

Table 2.8 Establishing the HACCP System in a Food Company (NACMCF,1997)

1. Decision by management to use the HACCP system
2. Training and formation of the HACCP team
3. Development of the HACCP plan document, including the following the following parts:
    - Assemble the HACCP team to develop HACCP procedures
    - Compile a complete description of the foodstuff.
    - Identify end-point uses of the foodstuff.
    - Develop and verify the flow diagram for process
    - Conduct a hazard analysis.
    - Determine the CCPs.
    - Establish critical limits.
    - Establish monitoring procedures.
    - Establish corrective actions.
    - Establish verification procedures.

- Establish documentation procedures.
- Validate the HACCP plan

4. Implementation of HACCP plan to establish and operate the HACCP system in the food company. The team plays a key role in these activities.
5. Verification auditing of the HACCP system, to determine that it is working correctly.

2.5.4.1 Hazard Analysis

Several studies have discussed the identification, monitoring, analysis of hazards, determination of critical control points, establishment and implementation of monitoring procedures (Bryan et al. 1992, Pierson and Corlett 1992, Codex 1997, Suwanrangsi et al. 1997, NACMCF 1998, Blaha 1999, Griffith 2000, McSwane et al. 2003, Sun and Ockerman 2005). Hazard Analysis is a vital component of the HACCP system. A working knowledge of potential hazards is necessary to perform hazard analysis for the development of HACCP plan. For the purpose of HACCP, hazards only refer to the conditions or contaminations in food that can cause illness or injury to the consumers. Hazard is a biological, chemical or physical agent or factor that cause an adverse health effect (NACMCF 1992). Hazard Analysis requires a good knowledge of aquaculture operations, access to technical literature and epidemiological data and a sound knowledge of the production environment. All the activities associated with production, harvesting, handling, storage and transportation must be evaluated. An important aid to hazard analysis is the process flow chart which documents all the major steps in an aquaculture operation. process flow charts may take many forms with some incorporating symbols to indicate sources of contamination, CCPs, inspection activities etc. Hazard analysis proved to be the most significant stumbling block in HACCP training (Taylor and Kane 2005). Hazards in aquacultured shrimp can be classified into three groups.

1. Biological hazards- Microbes, parasites, toxigenic animals,
2. Chemical hazards – Natural toxins, pesticides, heavy metals, antibiotic residues, cleaning compounds,
3. Physical hazards – Stones, sand, mud, bones, metal fragments, glass.

Hazard analysis involves the identification of hazards and assessment of the severity of the hazard. The severity of hazards and the probability of their occurrence is evaluated according to the epidemiological data about the foodstuff. Assessment of risk and severity makes the hazard analysis quantitative and thereby informative. Risk expresses the chance of a hazard occurring whereas severity relates to the magnitude of the hazard.

2.5.4.2 Identification of Critical Control Points (CCP)

The CCP is unique to the HACCP system, as all preventative and control measures are aimed at hazards which have been identified during the hazard analysis step. A CCP must be identified for each hazard. To be a CCP, an operation must be such that appropriate action will prevent, control or minimize the hazard. If a hazard can be controlled at more than one place, the most effective place to control it must be chosen. Cooking shrimps will control risks associated with contamination by food poisoning bacteria. Potential contamination of the pond environment may be minimized by using dry pelleted feeds rather than using fresh manure or controlling farm hygiene etc. To aid in deciding what operations are CCPs a decision tree has been developed (CAC 1997). The decision tree contains a logical series of questions which are asked for each hazard at each processing step. The answer to each question leads the HACCP team to a decision whether or not a processing step is a CCP. The HACCP team must consider what control measure should be taken to eliminate each food safety hazard. Sometimes more than one control measure may be needed to eliminate a hazard or more than one hazard may be controlled by a specific control measure. Examples of control measures are listed below:

1. Biological hazards- Time/ temperature control, thermal processing, cooling and freezing, hygienic practices, source control, drying, addition of salt or other preservatives etc.

2. Chemical hazards – Source control (vendor certification and raw materials testing) and production control (proper use and application of food additives etc.)
3. Physical hazards – Source control, production control, use of metal detectors, UV light etc.

2.5.4.3 Establish Critical Limits for Each CCP

The most important phase in the establishment of a HACCP system is translating CCP information into surveillance procedures which can be used in the production and processing environment. Critical limits define the boundaries between safe and unsafe products and practices. Critical limit is the criteria which separates acceptability from unacceptability. Hence they must be associated with a factor which can be measured and monitored on a routine basis. This involves defining product and process variables and their tolerances at each CCP. The application of drug or chemical during the growing period could be a CCP. Information for determining critical limits may be drawn from published information, expert advice, experimental data and mathematical modeling. Microbiological specifications should be avoided as the tests are time consuming and the results are not available rapidly. HACCP is based on the ability to take instant action when the process deviates, so microbiological analysis is typically used for verification purposes.

2.5.4.4 Establish Monitoring Procedures

If HACCP is to function effectively, a regular schedule for monitoring each CCP must be established. Monitoring should be undertaken by persons involved in the operation which involves making visual observations, sensory evaluations, taking physical measurements and testing of samples.It should be specified as to who will perform monitoring, what will be monitored, how monitoring will be done and when monitoring will be done.

2.5.4.5 Establish Corrective Action Procedures

When monitoring indicates deviation from the specified range or critical limits, immediate action must be taken to rectify the situation and get the process back under control. Corrective action is clearly defined beforehand under HACCP. This includes advice on how to correct the problem and bring back the process under control as well as guidance on isolating all affected product. All suspected products should be placed on hold until its safety is ensured. Corrective action is also important in the point of view of its importance in reviewing the process and preventing the recurrence of the deviation and the hazard. Corrective action in aquaculture practices includes extending of withdrawal period, thorough washing of harvested shrimp etc. The plan shall specify what are the corrective actions to be taken, who is responsible for taking the corrective action, what to do with products when process goes out of control and how documents of corrective action are maintained etc.

2.5.4.6 Establish Verification Procedures

The verification process assists in improving the HACCP system and determines whether the HACCP system achieves its goals. The HACCP system should be audited to assess whether it complies with the documented HACCP plan.The questions which may be asked during the verification process include whether the correct CCPs are selected, Have effective criteria for control been specified, are there control measures in place, are the monitoring activities effective, etc.Verification involves a thorough review of documentation as well as examination of all microbiological, chemical and physical test data to ensure that production operations are fully controlled. HACCP systems are in a constant state of evolution and the verification process assists in fine tuning the system to improve its effectiveness. If any change occurs in production or processing operations, a complete reassessment of the HACCP system is required as the hazards might have been changed which in turn necessitates a review of the CCPs.

2.5.4.7 Establish Documentation Procedures

Record keeping assists in carrying out verification activities, trouble shooting, data analysis for production improvements and to review production history. Records like HACCP plan, Product traceability, records of CCPs monitoring, corrective action, nature of coding, analytical details etc. should be properly documented.

2.5.5 Benefits of HACCP System

Several workers have discussed the benefits of HACCP system (Motarjemi et al.1996, Mortimore 2000, Sperber 2005b). The system can be considered an efficient tool for both industry and health authorities to prevent foodborne diseases if it is based on understanding and proper implementation, because it is not HACCP system itself which makes food safe, but its correct application (Mortajemi and Koaferstein1999, Mortimore 2000). The HACCP system can be integrated into the design of the process and thus provides a preventive and cost effective approach to food safety. The application of HACCP system leads to more efficient prevention of food borne diseases. It can be used as an inspection tool. The concept can be used to study food preparation practices and in the management of food safety programs. The HACCP system overcomes many of the limitations of traditional approaches in such ways as it avoids lengthy tests, large number of samples for inspection, high costs incurred in end product testing, the limitations of 'snap-shot' inspection techniques in predicting potential food safety problems etc. The HACCP system has the potential to identify all conceivable, reasonably expected hazards, even where failures have not previously been experienced and therefore particularly useful for new operations. The HACCP system is capable of accommodating changes introduced, such as progress in equipment design, improvements in processing procedures and technological developments related to the product. This system is expected to cause an improvement in the relationship between food processors and food inspectors as well as food processors and consumers. Moreover, the system is applicable to the whole food chain, from the raw material to the end product, i.e, growing, harvesting, processing or manufacturing, transport and distribution, preparation and consumption (Motarjemi et al. 1996). As far as a developing country is concerned, the potential benefits by the application of the HACCP system may outshine the problems that may arise. The HACCP system provides a cost effective and alternate approach to traditional food control, permitting the food safety risks to be pin pointed without necessarily having to resort to expensive microbiological and chemical analysis of foods except for verification purposes. Meeting food export requirements has generally been a strong motivation to introduce the HACCP system. Therefore, the concept is better accepted and increasingly integrated by food industries who are targeting their products towards the export market. Taylor (2001) discussed the benefits and burdens of implementing HACCP in small companies and found that the benefits overtake the burdens.

2.5.6 Concept and Application of the HACCP Approach

Several workers from different parts of the world have discussed the possibility of application of the HACCP approach (Bryan 1992, Jones 1998, Zaibet 2000, Matyjek et al. 2005, Noordhuizen and Metz 2005). According to Bryan (1992), the HACCP approach can be applied to food processing operations, foods processed in cottage industries as well as to those processed in advanced manufacturing plants, food service operations and food preparation practices at homes. This approach can also be applied to the production and harvesting of the crops, raising of livestock and poultry, fishing, harvesting of shellfish and the transportation, storage and marketing of foods. Pearson and Dutson (1995) discussed the development of HACCP in the field of seafood processing. HACCP principles were virtually ignored by the seafood industry until the late 1980s, except for low acid canned foods such as canned fish. Low acid canned seafoods were produced under HACCP controls because of regulations promulgated in 1973 which were instituted because of a Clostridium botulinum threat in canned mushrooms. In 1985, NAS indicated that HACCP can be successfully transferred to other food commodities with the particiption of the industry and the government. An evolutionary trend was evident thereafter as more and more HACCP application experts were giving credence to the use of sanitation critical control points and the expansion of HACCP beyond microbiology and low acid canned foods to include chemical and physical hazards and other commodity processes. Various aspects of HACCP have been explored for use in the seafood industry since the early 1970s. National Seafood Inspection Laboratory (NSIL) of National Marine Fisheries Service (NMFS) was the first to examine HACCP principle of hazard analysis in terms of integrated numerically weighted product risk potential. In this system, the risk potential indices were calculated from a detailed examination of the hazards associated with seafoods, such as harvest area, processing type, intended consumer group,etc. According to Pearson and Dutson (1995), Lee 1977, was one of the first to carry out investigations on the application of HACCP principles for seafood and recognize the importance of influencing factors, such as harvesting, consumer abuse potential, plant layout and construction, sanitation etc. in pinpointing CCPs. His contribution to seafood hazard analysis was the table on seafood hazard categories in order of decreasing risk which defines the hazard analysis rule of thumb still used today (Pearson and Dutson 1995).

Barendsz (1998) opines regarding HACCP certification that increasing number of companies are striving for a certificate, to realize both 'external benefits' as part of their market strategy and 'internal benefits' to open up a way to enormous improvements and efficiency. Food safety is a growing global concern not only because of its continuing importance for public health but also because of its impact on international trade. Jones (1998) has applied HACCP principles to a risk analysis of the hygiene related health hazards in a typical home and suggested that the consumer needs help to identify and classify the risks according to their significance and that the risk analysis techniques especially HACCP can serve as effective tools in controlling hazards in the food industry. Motarjemi and Koaferstein (1999) reported that HACCP is presently applied in large food industries and for foods which are destined for export. It is certain that a regulatory approach to HACCP implementation will not only improve the safety of foods aimed for export, but will also ensure that sufficient attention is given to the safety of food intended for the local population. Ababouch (2000) is of the opinion that the application of HACCP is the responsibility of the food industry, whereas government control agencies are responsible for monitoring and assessing their proper implementation. The main purpose of HACCP assessment is to verify whether the food processor is able to manufacture and or distribute safe and quality products which implies specific and complementary roles for the food industry and the government agencies. Zaibet (2000) has studied the perception and compliance of Oman fish processing companies to HACCP and reported that upto 1998 there was no requirement for plant-level quality management system and the regulations were based on regular inspections by government in contrary to the principles of HACCP. Baker (2002) has reported the use of food safety objectives and a HACCP based management system to resolve the conflict between the strict interpretation of food safety regulations and the commercial ability to serve rare roast beef and emphasized the need for a HACCP based food safety system to be implemented in restaurants. DeWaal (2003) recommended strengthening the safety of the US food supply by setting farm and animal production food-safety standards by improving the implementation of HACCP, also criticizes the US regulatory structure for being fragmented and calls for a single food safety agency. Several workers studied the level of HACCP implementation in small and medium size food businesses (Walker et al. 2003, Bas et al. 2007). Henroid and Sneed (2004) studied prerequisite food safety programs and HACCP implementation in school foodservice operations in lowa schools. Bas et al. (2006) studied the problems encountered in implementation of HACCP and PRP in food business in Turkey. Martin et al. (2003) reported Australia has worked towards uniform food legislation since 1908 and it now has a national food safety regulatory system consisting of: nationally consistent Food Acts; mandatory standards for food safety practices and food premises and equipment; a model standard for food safety programs and supporting infrastructure projects to assist with its implementation with the primary objective of reducing the incidence of foodborne illness by requiring food businesses to take responsibility for the safety of the food they handle and sell by moving towards a preventative approach to managing the food safety risks within their business. Chemat and Hoarau (2004) observed that the classical quality control methods are inadequate in the case of food and drinks processed making use of modern technologies like ultrasound which often cause hazards for product safety and demonstrates how they are effectively controlled through the implementation of HACCP concept. Matyjek et al. (2005) have assessed the actual situation in the food production and processing plants in Poland with the objective to implement quality assurance systems, GMP,GHP and HACCP and found that 91% of the surveyed plants are familiar with GHP rules, 95% with HACCP, 34% have already implemented the system and 35% are in the process of implementation. Noordhuizen and Metz (2005) while studying the HACCP based quality control approach of the Dutch dairy sector, anticipating application of HACCP-compatible programs on the dairy farms in future based on developments within the dairy sector as well as at the EU political level, have suggested that the quality assurance programmes should include the primary producers like the dairy farms as well, rather than focusing on the product milk alone, which will help in identifying and managing the quality hazards and risks occurring in the production process on dairy farms and in providing the consumer with more certainty about the quality of products of animal origin. Pearce et al. (2004) have studied the impact of pig slaughter and dressing processes on carcass microbiology and their potential use as CCPs during pork production and slaughter and have recommended that to reduce the risk of foodborne illness and to improve food safety, general hygiene standards alone are not sufficient. They also point out that the EU system which at present requires just hygiene standards to verify process control lacks the food safety element and this situation should be addressed through the implementation of HACCP. Sato et al.(2005) suggested that it is very difficult to apply the HACCP concept to the quality evaluation of raw fish 'Sashi' and that it can be better evaluated by time-temperature tolerance based on 'K' value. Scott (2005) has reported the ways in which the industries in United States validates elements of HACCP plans and stated that validation may involve the use of scientific publications, historical knowledge, regulatory documents, experimental trials and other approaches. Maldonado et al. (2005) have studied the costs, difficulties and benefits of HACCP implementation in the Mexican meat industry. Their results showed that investment in new equipment and microbiological tests of products accounted for most of the implementation and operational costs respectively. Patricia et al. (2005) have studied the barriers of HACCP team members to guideline adherence and reported that non-awareness to HACCP guideline was a major barrier and suggested that the team must be multidisciplinary in order to ensure guideline adherence. Zwietering (2005) suggested that the food safety objectives can be used to assign responsibilities over the various parts of the food chain and within one part of the chain over the various process stages, linking finally the limits of the CCPs in HACCP to the overall public health objective. Bertolini et al. (2006) described four scenarios in aquaculture and fishing product trade between developing countries and countries in the EU and reported that consumers have become increasingly concerned about the safety of food, including those derived from aquatic resources. According to Ababouch (2006), the globalization of fish trade, coupled with technological developments in food production, handling, processing and distribution, and the increasing awareness and demand of consumers for safe and high quality food have put food safety and quality assurance high in public awareness and a priority for many governments. Consequently, many countries have tightened food safety controls, imposing additional costs and requirements on imports. As early as 1980, there was an international drive towards adopting preventative HACCP-based safety and quality systems. More recently, there has been a growing awareness of the importance of an integrated, multidisciplinary approach to food safety and quality throughout the entire food chain (Ababouch 2006). Bertolini et al. (2007) proposed an alternative approach, the fault tree analysis (FTA) approach to HACCP system implementation which will help the quality/safety managers in the identification of risk priorities and of the related CCPs, by means of a structured, quantitative and qualitative methodology. Cormier et al. (2007) suggested that auditing to verify HACCP program implementation alone is not sufficient and there is a need to monitor final product also in seafood HACCP-based programs to measure the effectiveness and performance of the control systems, even though HACCP is expected to result in final product that consistently meet requirements.

2.5.6.1 Farm to Table Food Safety

Several workers have opined that the HACCP approach can be applied from 'farm to fork' (Bryan 1992, Blaha 1999, Motarjemi and Koaferstein 1999, Billy 2002, Sperber 2005b). Though the HACCP principles have been developed and applied to food processing sector, it has been pointed out (NACMCF 1992) that the HACCP approach can be used to help assure the safety of foods from production to consumption. Outbreaks of foodborne illness, some with tragic consequences, have raised widespread concerns about the adequacy from farm to table of the food safety system in the USA and the Food Animal Production Medicine Consortium, 1992, had emphasized the need to involve HACCP principles along the entire food chain as a means of increasing the safety of the foods of animal origin. The HACCP based quality assurance programs first developed by the livestock commodity organizations had been focused on the avoidance of antimicrobial residues in meat and milk. Two such programs were "Pork Quality Assurance" and "Milk and Dairy Beef Quality Assurance" program developed by the American Veterinary Medical Association and the National Milk Producers Federation. These organizations used residue avoidance programs using 10 CCPs. Thus other industries also started the implementation of HACCP concepts for on- farm application (Pearson and Dutson 1995). According to Suwanrangsi et al. (1997), HACCP is essentially a technique based upon anticipation and prevention of food safety hazards which may be applied throughout the food chain from producer to final consumer, leading to enhanced food safety. Blaha (1999) has discussed the impact of farm-to-table concept and the implementation of HACCP plans throughout the food production chain on animal production and veterinary profession with reference to pork production. Sperber (2005b) reported that even though the HACCP system was evolved at the food processing step of the farm to table food supply chain, the widespread success of this concept made its application possible along the entire food chain, from "Farm to Table. The USDA recognized that the safety of meat and poultry products can be assured only by the application of the "Farm to Table" concept and no CCPs can be applied at or after slaughter (Billy 2002). Sperber (2005b) pointed out that the occurrence of many outbreaks of food borne illnesses in spite of the widespread use of HACCP in the food industry, aroused serious concerns about food safety. Most often, these food safety failures were realized to be not HACCP failures but they were failures of cleaning and sanitation practices or lack of management awareness and commitment. The HACCP which was originally designed as a food safety management system, further expanded in practice to include the quality and hygiene parameters also(Wallace and Williams 2001). Such expansion of HACCP beyond its original concept, as believed by many HACCP practitioners, produced a system that is less effective as a food safety control mechanism. This resulted in the genesis of a new concept, the 'Pre- requisite programs'.

2.5.7 Pre- Requisite Programs

A number of definitions have been proposed for PRP. The WHO has defined PRP as the "Practices and conditions needed prior to and during the implementation of HACCP and which are essential for food safety" (WHO 1993). The NACMCF, (1997) defines PRP as "procedures, including Good Manufacturing Practices, that address operational conditions providing the foundation for the HACCP system". These programs include areas such as supplier control, temperature monitoring, personal hygiene standards and pest control and often are addressed through sanitation standard operating procedures. Many HACCP practitioners believe that the Codex International Code of Practices General Principles of Food Hygiene is the basis for PRP (Codex, 1997) which state that "prior to the application of HACCP to any sector of the food chain, that sector should be operating according to the general principles alongwith appropriate Codex Codes of Practice and appropriate food safety legislation". In other words, these are seen as pre requirements or prerequisites to HACCP. The Canadian Food Inspection Agency (1998) defines PRP (PRP) as the " universal steps or procedures that control the operational conditions within a food establishment allowing for environmental conditions that are favorable for the production of safe food". Mortimore and Wallace(1998) described PRP as the HACCP support network which shows the inter relationship of management systems and procedures in any food business for the production of safe, high quality products. The British Retail Consortium (1998) has published a Technial Standard for Suppliers of Own Label Food Products which comprises six sections: HACCP System, Quality Management System, Factory Environmental Standards, Product Control, Process Control and Personnel, of which the last four might be considered as PRP. The UK Expert HACCP Steering Group (1999) calls PRP a 'premises program', 'sanitation and pest control' and an 'equipment program'. Seward (2000) has recommended that a PRP is needed before HACCP is utilized. According to Wallace and Williams (2001), the concept of PRP has been evolved from the concept of GMP which have been employed by the food industry for many years. They point out that the PRP include elements such as cleaning, operator and environmental hygiene, plant and building design and preventive maintenance, previously and still frequently described as GMP. PRP, which support HACCP plan, also called standard operating procedures (SOP), includes employee hygiene practices, cleaning and sanitation programs, proper facility-design practices, equipment maintenance and supplier selection and specification programs or cross-contamination control (National Restaurant Association Educational Foundation, 2002).

Ciapara and Orozco (2000) noticed even though the seafood HACCP system integrated into the official regulations of different countries(Mexico, USA and the European Union) is based on the seven principles of HACCP, they present important differences in scope and format of the PRP, technical recommendations and content of the HACCP plan. Jeng and Fang (2003) reported that food safety control system (FSCS) in Taiwan includes good hygienic practice (GHP) and HACCP, and is fully compatible with international codes adopted by CAC and helps in maintaining the safety of foods not only in domestic market but also in international trade. Awua et al. (2007) found application of GMP and HACCP to be effective as a quality management system for assuring the safety of kenkey in the traditional processing of maize into kenkey and as a prerequisite program, the facility was upgraded and GMP implemented before HACCP.

2.5.7.1 Need for HACCP and Pre Requisite Programs

Despite the wide spread use of HACCP in the food industry in USA, many outbreaks of foodborne illnesses still occurred which made the HACCP practitioners recognize that HACCP is a necessary, but insuffficient condition to assure food safety. The NACMCF does not recommend use of HACCP for reasons other than assurance of food safety, because broad application for noncritical matters would dilute the effectiveness of HACCP. It was recommended that traditional quality control programs be used for most routine attribute control functions (Corlett 1998). The PRP were thus identified as a critical component of HACCP implementation. Many authors opined that the inclusion of CCPs in HACCP which are not true CCPs can cause major problems in practice. If PRP are there, such control points which are not critical can be grouped under pre requisites (Wallace and Williams 2001). However, some people believe that all important issues should be part of HACCP and anything managed outside the HACCP plan will be forgotten. Some people consider the potential for hindering HACCP development and its effectiveness as failings of PRP. Some others believe that HACCP should be enough on its own and that two systems are a duplication of effort rather than complimentary ways of managing safety and HACCP (Wallace and Williams 2001). In some countries, there is already some formalization in the use of pre requisites. The 1996 Pathogen Reduction and HACCP rule of the FSIS, USA requires all meat and poultry plants to develop and implement separate written standard operating procedures for sanitation as well as HACCP system to prevent food safety problems. Similarly, US FDA requires the pre requisite of GMP for all food producers and lists HACCP for only seafood production (Wallace and Williams 2001). The food safety strategy of the FSIS which encompasses the entire farm-to-table chain requires both mandatory SSOP and mandatory HACCP (Billy 2002). Many HACCP practitioners suggested that developing PRP is one of the first steps towards building effective HACCP systems (Henroid and Sneed 2004) and PRP provides a solid foundation to develop HACCP and that food industries need to implement PRP before they can be ready for HACCP implementation (Bas et al. 2006). The PRP can support HACCP effectively and the resulting streamlined

HACCP plans can be easier to manage. PRP are found to be very effective in prioritizing activities in certain factories in less developed countries. It may also be a useful starting point with companies who have a longer way to go to achieve HACCP. Many small and medium sized food businesses also benefit from getting the pre requisite foundations laid before endeavoring to use HACCP. If there are clearly laid down pre requisite requirements, the differentiation between HACCP and pre requisites may be quite straightforward. Completing pre requisites may take time, money and effort especially for implementing documentation and records. In such cases, there is a tendency to do HACCP even though it is unsupported, however, as soon as things go wrong, the importance of PRP as foundation for simple straightforward HACCP will soon be realized. According to (Sperber 2005b), HACCP cannot be effective when applied as an isolated system, it must be supported by PRP, examples of which are listed in Table 2.9. The PRP developed for the US meat industry and produce industry are also listed in Table 2.10 and 2.11 respectively.

Table 2.9 PRP commonly used in food processing industry from Sperber (2005b).

Cleaning and sanitation	Personal hygiene
Purchasing requirements	Water/ ice/air control
Pest control	Maintenance
Labelling	Transportation
Rework	Product retrieval
Facility and equipment design	Allergen control
Supplier approval	Chemical control
Employee training	Product specifications
Foreign material control	Product storage control
Good agricultural practices	

Table 2.10 Interventions that could be used as food safety control measures in beef animal production and slaughter from Sperber (2005b).

Clean, chlorinated drinking water	Clean transportation
Adequate pen management	Hide cleaning
Food contamination prevention	Organic acid sprays
Vaccine, antibodies, bacteriophage	Sanitizer sprays
Antibiotics	Steam vaccum cleaning
Clean feed bunkers	Thermal pasteurization, steam or hot water
Feed additives	Carcass spacing in cooler
Competitive exclusion	

Table 2.11 Good Agricultural Practices for use in produce production and harvest from Sperber (2005b).

Water quality	Worker health and hygiene
Land history and surrounding properties	Containers and packaging material
Soil amendments	Tools and equipment
Field sanitation	Transport
Pest control	Post harvest cooling
Agricultural chemicals	Storage
Worker sanitation facilities	Product traceability

2.5.8 Development of Safety and Quality Management System

Several studies have examined the barriers to HACCP implementation in food businesses from different parts of the world (Gilling et al. 2001, Panisello and Quantick 2001, Vela and Fernandez, 2003, Walker et al. 2003, Matyjek et al. 2005, Patricia et al. 2005, Taylor and Kane 2005). Many studies reported lack of PRP as one of the factors hindering the development of

HACCP. Studies have indicated that the PRP can be used to work effectively with HACCP and the accepted approach is to control significant hazards with the HACCP plan and to keep generalized GMP/hygiene issues to the PRP where they are less likely to cloud the HACCP plan or divert attention from the essential controls, the CCPs (Mortimore 2000). In some countries, it has been the practice to include quality issues and GMP/hygiene issues in HACCP plans which has led to the overcomplication of HACCP. The inclusion of CCPs in HACCP which are not true CCPs can cause major problems in practice (Wallace and Williams 2001). Wallace and Williams (2001) suggested that the problem is with the terminology and not with the concept. HACCP only has CCPs. Using other terms such as critical controls, control points, relative risk points, quality control points and political control points within the HACCP plan simply serves to confuse and to dilute the effectiveness of the one concept, the CCP to control safety (Wallace and Williams 2001). Another possible failure might be considered as the other extreme where the HACCP plan has been developed to cover only significant food safety hazards but no formal PRP are in place as support. In such cases, the major food safety hazards would be covered but the overall system will be weakened by lack of support (Wallace and Williams 2001). Several researchers have pointed out that formal PRP are needed to support the implementation of HACCP (Seward 2000, Mortimore 2001, Wallace and Williams, 2001, Walker and Jones 2002, Henroid and Sneed, 2004). It is also possible that a company might develop PRP and HACCP and yet fail to link the systems together (Wallace and Williams 2001, Vela and Fernandez 2003). Here, the issues are either duplicated or missed due to assumptions that one or the other system already covers them (Sperber 2005b).

The solution to overcome all such problems was recommended to be through the use of an integrated approach and consequently a few workers suggested management of safety and quality in a total quality management system (Ababouch 2000, Griffith 2000, Sperber 2005b, Bertolini et al. 2006). A few workers also developed models incorporating safety and quality aspects (Mortimore and Wallace 1998, Mortimore 2000, Wallace and Williams 2001). Mortimore and Wallace (1998) described PRP as the HACCP support network and designed a model which shows the inter-relationship of management systems and procedures in any food business for the production of safe, high quality products. Processing flow charts incorporating the possible CCPs and SOPs were developed (Griffith 2000, Soriano et al. 2002). Studiės have pointed out that there is a big confusion between PRP and HACCP plan, their relations and how they should be managed (Mortimore 2001) mainly because of negative guideline factors and lack of understanding (Vela and Fernandez 2003). Mortimore (2000) designed a quality management system which takes into consideration all the controlling points, the safety hazards addressed through the HACCP system and the quality and hygiene issues met with through the PRP. Wallace and Williams (2001) indicated that it is important to formalize the approach for both HACCP and PRP, allowing effective control of all issues which will include assessing the current situation and any gaps in the systems, careful planning of the requirements for a facility's food safety management programme, followed by development and documentation of the chosen approach. For both systems, effective implementation and day to day monitoring are essential to demonstrate control of food safety hazards and GMP/hygiene issues. Verification and maintenance of the systems will form an important progression and will thus ensure effective food safety control into the future. According to Wallace and Williams 2001), this can be achieved by managing both HACCP and PRP within a quality management system such as ISO 9000. In a HACCP-based program, it is the entire system of CCP's, processes, handling practices, sanitation cycles, monitoring procedures, corrective actions and even employees abilities and attitudes that have to operate flawlessly to ensure that the product is compliant from batch to batch or manufacturing cycles (Mortimore 2001).

HACCP approach requires food products to be prepared or processed in certified plants and establishments which requires that the plant meets minimal requirements in terms of layout, design and construction, hygiene and sanitation and suggests that the verification of prerequisite programs can be carried out concurrently with the HACCP assessment in order to have an overall assessment of safety and quality management especially for processors who use the HACCP approach to address GMP/GHP implementation as well (Ababouch

2000). Several researches had concluded that studies about HACCP in foodservice areas are important because it can support the future development of hygiene legislation to provide safe foods from farm to fork (Soriano et al. 2002; Walker and Jones 2002). The impact of licensing on food safety has been reported (Walker et al. 2003) citing the example of butcher's shop licensing, stated that butcher's shop licensing in the area studied has clearly improved food hygiene standards and licensed premises were able to demonstrate better comprehension of food safety issues, including the ability to recognise hazards and understand how control measures work and effectively link these into their existing operations. Proponents of the former ''inspect as you go'' approach argue that some form of product monitoring is still required to verify the implementation of HACCP-based programs (Cormier et al. 2007).

xxx

Chapter - 3
METHODOLOGY

3.1 Introduction

A convenience sample of 115 shrimp farms *(Penaeus monodon)* and 14 shrimp hatcheries *(Penaeus monodon)* from 5 different districts (Alappuzha, Kannur, Kochi, Kollam, Thrissur) was selected from the state to study the possibility of implementing HACCP and PRP in shrimp farming and shrimp hatchery operations. These districts were selected purposively because the shrimp farming operations were mainly done in these areas. Twenty, five, thirty five, twenty five and thirty nos. of farms were selected from the districts of Alappuzha, Kannur, Kochi, Kollam and Thrissur respectively. Participants were selected on the basis of the recommendations from the regulatory agency officers. It was requested that the selected farms and hatcheries be in operation for not less than 5 years and the farms be of moderate size (<3ha) and independent. Random identification numbers were used for identifying farms and hatcheries throughout the study to maintain confidentiality. Baseline assessment of the farms and hatcheries consisted of three components: an on-site visit, an interview with the shrimp farm and hatchery managers and a test of farmer's and hatchery operator's knowledge and attitudes about food safety and quality through HACCP and PRP questionnaires. Semi-intensive aquaculture was practiced in all the farms and the shrimp samples collected were cultured for 60 to 70 days. The post larvae were cultured for 20-22 days. The water, sediment and shrimp samples for the physico chemical and bacteriological tests were collected as per recommended procedures. The water samples were analysed for PH using a PH meter, total suspended solids, total organic carbon, nitrate, surfactants, COD and BOD were analysed using Pastel UV and all the other physico-chemical parameters determined as per procedures outlined in APHA (1998). The bacteriological analysis was carried out as per the methods outlined in USFDA (1984). The total plate count was estimated by the pour plate method and the total coliforms, faecal coliforms and faecal streptococci were estimated by the MPN method. Chloramphenicol was estimated by the LCMS-MS and CHARM-II methods. The organo chlorine pesticides content, heavy metals and sulphite content analysed as per standard procedures (AOAC 1995).

3.2 HACCP and PRP Questionnaires

There have been two stages in this study. During the first stage, the HACCP principles awareness of the farmers and hatchery operators was collected using HACCP questionnaires. These questionnaires were prepared and evaluated based on the cognitive-behavior barrier model to HACCP principle adherence designed by Patricia et al. (2005) and the HACCP awareness to adherence model proposed by Gilling et al. (2001) grouping data in three levels to identify most important barriers, and illustrated in Fig.3.1 and Fig.3.2 respectively. The questionnaires included questions related to demographics, HACCP knowledge, attitudes and behavior.

In the second stage, the PRP questionnaire was used which consists of three parts. Part 1 of the shrimp farmer's questionnaire included fourteen questions related to pond preparation practices, eight questions related with fertilization, ten questions on water quality management, ten questions related with seed and stocking practices, eight questions on feed management, seventeen questions on chemicals management, eleven questions on health and disease management and ten questions on harvesting and post harvesting aspects. Part II consists of five attitude questions related with awareness and implementation of PRP such as good aquacultural practices and hygiene procedures. Part III of the questionnaire consisted of a list of twenty seven practices that would indicate the presence of PRP. The PRP questionnaire was prepared based on Suwanrangsi et al. (1997), AAI (2002), MPEDA/NACA (2003), Ravichandran and Pillai (2004), GESAMP (2005) and Subasinghe (2005) and the detailed PRP questionnaire is given in Appendix 1.

The PRP questionnaire developed for the hatchery operators consists of three parts. Part 1 included nine questions related to selection and management of broodstock, ten questions related with spawning and hatching management, seven questions on larval management and five questions related with post larval management, twenty four questions on feed management including algal and artemia culture aspects, nine questions on seawater quality management, five questions on health management, seventeen questions on chemicals management, two questions on inspection and transportation, four questions on infrastructural facilities and nine questions on general aspects. Part 11 of the questionnaire consisted of a list of forty five practices that would indicate the presence of PRP for HACCP. Part III consists of seven attitude questions related with awareness and implementation of PRP. The PRP questionnaire was prepared based on Joshua et al.(1996), AAI (2002), MPEDA/NACA (2003), Ravichandran and Pillai (2004), GESAMP (2005) and Subasinghe (2005) and is given in Appendix 11. Assessments of the 115 shrimp farming operations and 14 shrimp hatchery operations were conducted over one and a half years and the farmers and hatchery operators were contacted by telephone or in person six months after the PRP survey.

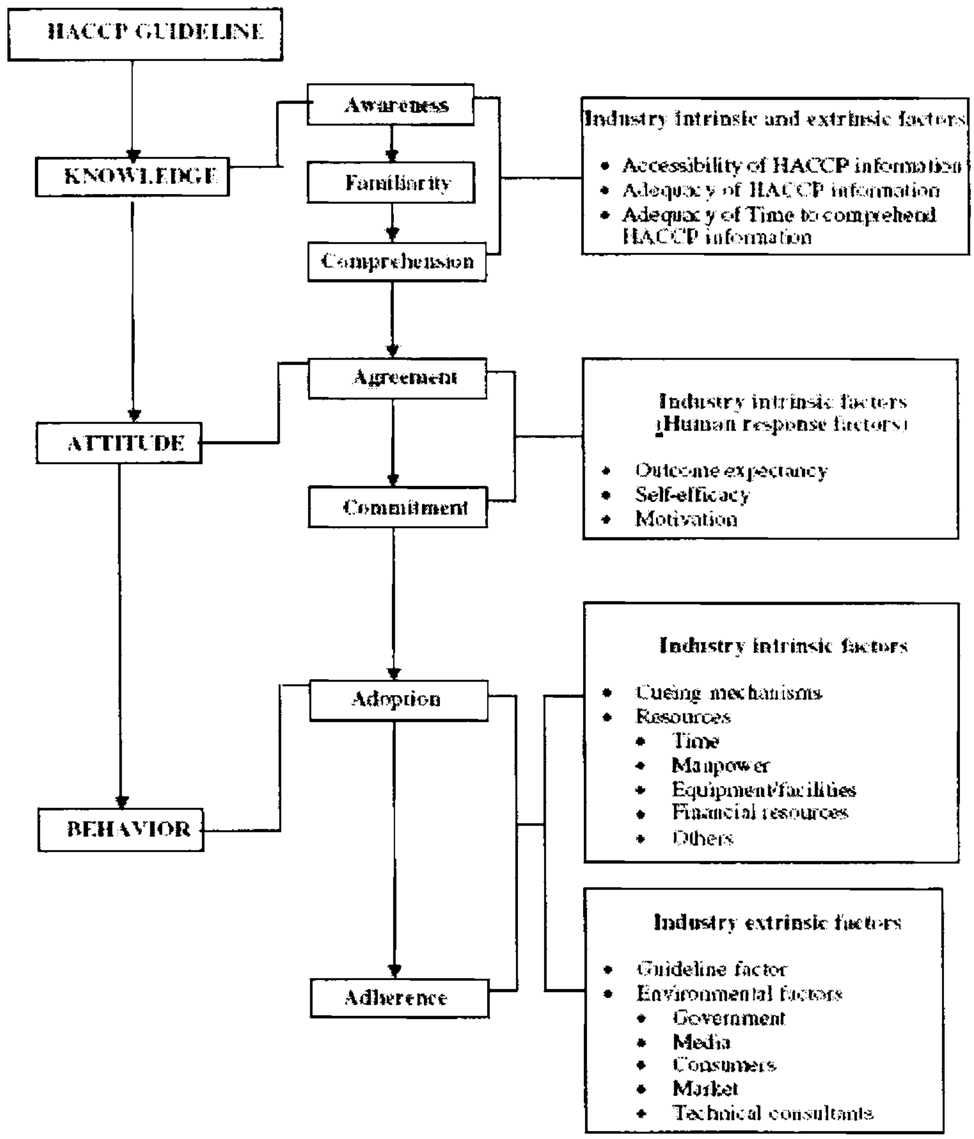

Fig.3.1 Cognitive and behavior model to HACCP principle adherence from Patritia et al. (2005).

3.3 Quantification of HACCP and PRP Compliance

During the visit, each step of the process was evaluated to assess if control measures existed and if they were being implemented. A scoring system for the questionnaires, was used to quantify their HACCP and PRP compliance. Before data analysis, responses were converted to numeric values, actions were converted into scores to make determinations. A response of "yes" indicated that the practice was present or that practice was observed being done properly during the observation time. Some items were responded on 4-point Linkert scale: Full compliance (3-point), minor deficiency (2-point), major deficiency(1-point) and non-compliance(0-point). Full compliance indicated that the observed procedure was performed correctly, minor deficiency indicated that the observed procedure was followed with some minor deviation, major deficiency indicated that the observed procedure was followed with major deviation and non compliance indicated that the observed procedure was not being followed. The PRP attitude questions were responded on 5-point Linkert scale: strongly disagree-1, disagree-2, neutral-3, agree-4 and strongly agree-5. In addition to observations, objective measurements such as farm water temperatures, PH, salinity etc were done and water and shrimp samples collected for different analysis using recommended procedures.

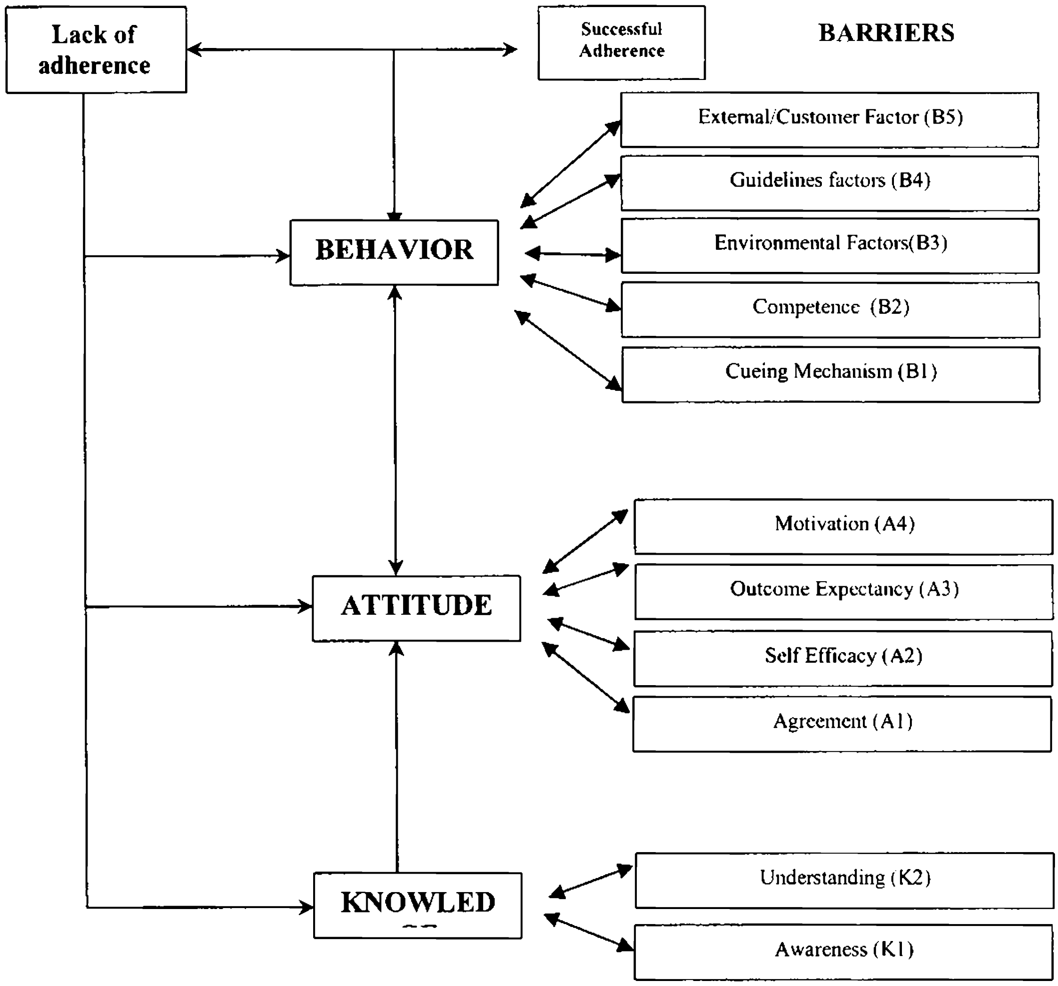

Fig.3.2. The HACCP awareness to adherence model from Gilling et al. (2001)

3.4 Determination of Heavy Metal

About 10g of accurately weighed asmple was transferred to a round bottom flask.To it about 10ml of conc. HNO_3 and 5ml of conc. HClO (2:1-v/v) were added and kept overnight for predigestion. The predigested sample was transferred to a digestion unit for oxidation of the organic matrix. Oxidation was carried out by the wet digestion method using a circulating water condenser. Digestion was continued until the sample solution became clear.The sample was cooled and the volume made upto 100ml with MilliQ water of conductivity 18.2uS. Similarly, a reagent blank was also prepared. The determination of heavy metal concentration except Mercury was done using a Flame Atomic Absorption Spectrophotometer,(Varian spectra-220 Model). The standard calibration graph was prepared using different metal standards. An Air Acetylene flame was produced and the wavelength was optimized for each metal using respective Hollow metal Cathode Lamps.

3.5 Determination of Organo chlorine pesticides

About 40g of the shrimp meat was ground with anhydrous sodium sulphate for dehydration and the lipid extracted with petroleum ether (60-80°C) and vacuum flash evaporated to 1 ml. The pesticide residues were separated by liquid partition using acetonotrile saturated with petroleum ether (60-80°C) followed by flurosil column chromatography first by using petroleum ether (60-80°C) containing 6% diethyl ether and then with petroleum ether (60-80°C) containing 15% diethyl ether. This was dried by anhydrous sodium sulphate, vacuum flash evaporated and dissolved in 1 ml petroleum ether (60-80°C). Pesticides were analysed in a varian GC 3700 fitted with EC detector and Alltech' pesticide mega bore column 0.5ux30m length FS CoT; at an injection temperature 250°C and detection temperature 300°C using imported pesticide standards.

3.6 Determination of Chloramphenicol

3.6.1 Determination of chloramphenicol using LC/MS/MS/System.

Detection of chloramphenicol was carried out in three steps; First step involved the extraction of chloramphenicol by ethyl acetate. Extract purification by partition liquid-liquid was carried out in the second step followed by quantification and identification on LC/MS/MS/System.

Sample preparation

2g of sample was blended in 6ml ethyl acetate in a rotary stirrer 100rpm/min. for 10 minutes. The homogenate was centrifuged at 4000rpm for 10 minutes. The supernatant was separated and transferred into a test tube ,dried under nitrogen, the residue dissolved in 1ml Hexan-CCl4 (1:1,v:v), 1ml water added, mixed slowly in a vortex for 5 minutes, transferred to plastic vials, centrifuged for 5 minutes, filtered to LC vials and the vials were kept in the HPLC system for estimation of Chloramphenicol.

Conditions for the HPLC estimation of Chloramphenicol

Flow rate; 0.6ml per min., Eluant: Ammonium acetate buffer 0.01m/Acetonitrile, Volume injected:100ul, Retention time: 5 min. HPLC Pump (Hewlett Packard Type 1100: G1311 A) Automatic injector HP G1313A; column: waters symmetry c18 150x 3.9mm internal diameter. APCI interphase (P.E.SCIEX), Mass Spectrometer API 2000 (P.E.SCIEX), data station; DELL with Analyst software.

3.6.2 Determination of chloramphenicol using CHARM II system.

The CHARM tests use two types of bacterial cells (binding reagent), one which contain natural antibiotic receptor site on or within the cell and the other cells coated with antibodies and a radiolabelled antibiotic. The tissue supernatant was added to a freeze dried pellet of binding reagent in a test tube and the sample was mixed and incubated during which any antibiotic present in the tissue bind to its specific natural or antibody receptor site on the bacterial cell.

Tracer reagent was then added to the mixture and the sample was mixed and incubated when any unbound receptor sites on the bacterial cell bind with the radiolabelled antibiotic. The sample was then centrifuged to collect the bacterial cells in the bottom of the test tube, resuspended in a scintillation fluid and mixed. Binding was measured with a scintillation counter and compared to a positive and negative control. The interpretation table and standard reference table for chloramphenicol are shown in Table 3.1 and 3.2 respectively.

Table 3.1 Interpretation table for chloramphenicol

Count	Interpretation
1-100	Background noise (Repeat the test with ten times dilution)
101-1750	Positive, contains chloramphenicol (Refer standard table)
1751-2000	Suspect, repeat the test (If same result obtained, declare as negative)

Table 3.2 standard reference table for chloramphenicol

Standard table	Count
0.1 0 ppb	1869
0.2 5 ppb	1446
0.50 ppb	910
0.80 ppb	791
1.00 ppb	635

Chapter - 4

ASSESSMENT OF ADHERENCE TO HACCP PRINCIPLES AND PRP IN SHRIMP FARMING OPERATIONS

4.1 Introduction

Hazard analysis critical control point (HACCP) is a food safety tool that is more recently advocated by international and national regulatory institutions as either voluntary or mandatory prescription to food processing (Gilling et al. 2001, Taylor 2001, Wallace and Williams 2001). Despite the orchestrated efforts of international institutions like Codex Alimentarius Commission (CAC) to drum up HACCP awareness and compliance, only food industries in more developed countries are currently apt to immediately implement this food safety tool (Patricia et al. 2005). Several workers have suggested the importance of 'farm to table' food safety (Blaha 1997, Billy 2002, Sperber 2005b, Bas et al. 2006). Investigations on the application of HACCP principles for seafood were carried out (Ciapara and Orozco 2000, Keerativiriyaporn 2000, Ababouch 2006, Bertolini et al. 2006). The need for implementing HACCP in shrimp aquaculture has been reported (Suwanrangsi et al. 1997, Anon 2004). The socio-economic profile of shrimp farmers of Nellore in Andhra Pradesh and Nagapattinam in Tamil Nadu and the extent of adoption of shrimp culture technologies have been studied (Kumaran et al. 2001, Lekshmi et al. 2005, Deboral et al. 2006, Reddy et al. 2007, Kumaran et al. 2008). Several workers have suggested the implementation of GAP/BMPs in shrimp aquaculture (Stanley 2000, Boyd 2003, Sebastian and Ramachandran 2005). Studies on the impact of implementation of BMP's in aquaculture is of late (Reddy et al. 2007, Subasinghe et al. 2007, Umesh et al. 2007). The implementation of BMPs and cluster management approach in the Asia-Pacific region has been reported (Padiyar et al. 2007). Subasinghe (2005) has discussed an epidemiological approach to aquatic animal health management to control diseases affecting the small-scale shrimp farming sector in southern India. Graslund et al. (2003) have studied the chemicals and biological products used by the shrimp farmers in Thailand, Boyd and Massaut (1999) studied the risks associated with the use of chemicals in pond aquaculture. Several workers have studied the microbiological aspects of brackish water shrimp farming (Surendran et al. 2000, Sung et al. 2001, Abraham et al. 2004, Gopal et al. 2005). The impact of aquaculture on the coastal zone has been studied (Primavera 2006). Boyd (2003) has prepared the Guidelines for aquaculture effluent management at the farm-level. The impact of cultured shrimp export on the Southeast Asian macro-economy has been described (Mulekom et al. 2006). Shang et al. (1998) have studied the comparative economics of shrimp farming in Asia. The economic impacts of HACCP regulations have been studied (Crutchfield et al. 1997, Jensen et al. 1998). HACCP as a more cost-effective approach to achieving improved food safety than alternative approaches has been suggested (Unnevehr and Jensen 1999). Caswell and Hooker (1996) indicated that adoption of HACCP as a regulatory standard has been motivated first by food safety concerns, and only second by a desire to facilitate trade. Several studies have examined the barriers to HACCP implementation in food businesses from different parts of the world (Gilling et al. 2001, Panisello and Quantick 2001, Vela and Fernandez 2003, Walker et al. 2003, Matyjek et al. 2005, Patricia et al. 2005, Taylor and Kane 2005). The occurrence of many outbreaks of food borne illnesses in spite of the widespread use of HACCP in the food industry, were realised to be failures of cleaning and sanitation practices or lack of management awareness and commitment and the new concept, the PRP was formed to address these quality and hygiene parameters. Several researchers have pointed out that formal PRP are needed to support the implementation of HACCP (Mortimore and Wallace 1998, Mortimore 2001, Wallace and Williams, 2001, Henroid and Sneed, 2004, Bas et. al, 2006). Studies to determine food safety practices and procedures related to HACCP programme and PRP implementation in other fields have been conducted (Jeng and Fang 2003, Henroid and Sneed 2004, Bas et al. 2006, Awua et al. 2007, Bas et al. 2007). However, studies conducted to examine the possibility of implementing PRP and HACCP in shrimp farming operations is limited (Suwanrangsi 2000). Studies examining the possibility of implementing PRP and HACCP in shrimp farming as well as the extent to which safety programmes are implemented in shrimp farming operations in Kerala are scanty. The very limited research in this field forced me to take up this study. This chapter presents a survey in five major shrimp farming districts of Kerala to identify the presence of PRP and HACCP in shrimp farming operations.

4.2 Methodology

A sample of 115 shrimp farms *(Penaeus monodon)* from 5 different districts was selected to study the possibility of implementing HACCP and PRP in shrimp farming operations. Selection of respondents and method of assessment were as detailed in Chapter 3.2. There have been two stages in this study. During the first stage, the HACCP principles awareness of the farmers was evaluated using a HACCP questionnaire and in the second stage, the PRP questionnaire, which was designed to obtain information with respect to the farming knowledge, attitudes and practices was used.

4.3 Results and Discussion

4.3.1 Profile of Shrimp Farmers

The majority of the shrimp farmers participated in the study had 10 or more years of farming experience and were between the ages of 50 and 65 years. Studies by Lekshmi et al. (2005) on the socio-economic profile of shrimp farmers of Nellore in Andhra Pradesh and Nagapattinam in Tamil Nadu revealed that 40% of the shrimp farmers had collegiate level of education and they had medium levels of farming experience. Reddy et al.(2007) found that majority of the shrimp farmers belonged to the age group of 30-40 years literate with 5-15 years of shrimp farming experience. The assessment of shrimp farmer's knowledge and attitudes about food safety and quality through questionnaires as well as observation of farmer's shrimp farming practices were conducted during the survey period.

4.3.2 Assessment of Adherence to HACCP Principles

Gilling et al. (2001) have proposed a HACCP awareness to adherence model, showing eleven potential knowledge, attitude and behavior related barriers involved in failures of HACCP guideline adherence. The cognitive-behavior barrier model to HACCP adherence designed by Patricia et al. (2005) describes the sequence of barriers that must be overcome by the respondents to finally reach a point conducive to HACCP adherence which starts with knowledge acquisition followed by proper attitude development leading to eventual behavioral change targeting adherence. To evaluate the results, the model proposed by Patricia et al. (2005), illustrated in Fig.3.1, was followed.

In the present study, the farmers were individually asked to respond to the HACCP questionnaire using the face-to-face narrative interview technique. Results of the study were tabulated and the percentage distributions calculated (Table 4.1). Under the knowledge barrier, 37.39% of the farmers reported to be aware of HACCP and the score obtained for non awareness of HACCP principles was 53.92%. In this study, very few farmers (8.69%) had reported that they are familiar with the term, HACCP and most of them could not explain what it involved. Their awareness did not go beyond having seen or heard the mere term. Of those who were aware of HACCP the majority had acquired information from their local enforcement agency officer. Other sources of information included fellow farmers, seminars or workshops and trade associations. Moreover, the term was included in the question 'Have you heard of HACCP' and the questions were with just 'yes' or 'no' answers. They claimed that their lack of HACCP awareness was due to lack of training. In a similar study conducted among meat and beverage processors in Philippines, Patricia et al. (2005) found that most of the respondents were not aware of HACCP principles and tasks and familiarity was the highest knowledge level achieved among the respondents. Gilling et al. (2001) identified lack of awareness of the HACCP guidelines as one of the technical barriers restricting HACCP guideline adherence in food processing establishments in U.K.

Table 4.1 Barriers to HACCP principles adherence by the shrimp farmers

Barrier	**Sub categories**	**% distribution (%)(n=115)**
Knowledge	Non-awareness	53.92
	(No previous exposure to HACCP principles)	37.39
	Awareness	
	(Once heard or read)	8.69
	Familiarity	
Attitude	(>1 exposure but without full understanding)	8.69
	Agreement	15.65
	(Full-belief in HACCP principles)	
	Commitment	75.66
	(Pledge to adopt)	
Behavior	No response	NA
	(Lack of knowledge of HACCP principles)	
	No response	
	(Lack of knowledge of HACCP principles)	

n= number of shrimp farmers, NA=Not asked

With respect to the attitude barrier agreement, 8.69% of the farmers expressed full belief in HACCP principles. 15.65% of the farmers reported commitment while non response dominated with 75.66%. At behavior level, no questions were asked since lack of knowledge of HACCP principles was assessed. Patricia et al. (2005) found that the respondents showed an optimistic attitude toward HACCP guideline implementation despite their low HACCP knowledge competence level. Gilling et al. (2001) reported that right attitude should be supported by the appropriate industry intrinsic and extrinsic environmental factors to facilitate HACCP compliance. In a survey conducted in Madrid to identify the barriers which are obstructing the implementation of HACCP programs in food companies, Vela and Fernandez (2003) identified problems at attitude level which obstruct the change of behavior and suggested that regulatory agencies should work to publish clear and detailed HACCP and pre requisite guidelines in vernacular languages to promote better understanding. Similarly, Bas et al. (2007) reported lack of knowledge about HACCP, lack of prerequisite programs and inadequate physical condition of the facility were the barriers for implementing HACCP and food safety systems in food businesses in Turkey. Training programs, both basic food safety and HACCP to support implementation of PRP and HACCP in food businesses were suggested In the present study, the low HACCP knowledge level of the shrimp farmers may be due to the inadequate and inappropriate information dissemination systems available in the country. Similar observations have been made by other workers also. Deboral et al. (2006) noted that most of the technologies do not reach the farmers when they are in need due to the weak Research-extension-farmers linkage system available in Tamil Nadu. SanthanaKrishnan and Rajesh (1995) opined that the social responsibility of promotional agencies lies in disseminating the aquacultural information in the form of seminars and trade fares at strategic venues so that the farmers get updated on current information. Chandra (2000) found that the farmers wanted the consultants to visit them periodically and provide information about the farm activities and first hand information and advice from Research institutions. The farmers expect technical information to be circulated in the form of handouts and simple publications (Deboral et al. 2006). Reddy et al. (2007) reported that the farmers with good R&D backup could succeed in managing the farming enterprise successfully amidst growing adversities.

In the present study, in the first round itself it was understood that the awareness of the farmers with respect to HACCP concept was very poor and so in the second stage, this survey was limited to PRP (GAP) awareness, attitude and practices only. The concept of PRP as a support system for HACCP has been recommended by different workers from various countries (Corlett 1998, Mortimore and Wallace1998, Seward 2000, Mortimore 2001, Wallace and Williams 2001, Sperber 2005b).

4.3.3 Assessment of PRP Awareness and Shrimp Farming Practices

The same farmers who were selected for the HACCP adherence study were selected for the PRP awareness, attitudes and practices study. The farmers were contacted six months after the PRP survey. Information is the first unique input to proceed further towards an enterprise building. Aquaculture sector needs to be supported with full information to help every stakeholder to help themselves (Kumaran et al. 2008). PRP awareness on aspects mentioned under 4.3.3.1 to 4.3.3.9 was collected and evaluated.

4.3.3.1 Pond Preparation

Several studies have identified certain risk factors such as removal of bottom sludge, ploughing on wet soil, use of lime etc. that can significantly reduce the risk of disease outbreaks and improve shrimp production (MPEDA/NACA 2003). The questions on pond preparation to check the awareness are given in Table 4.2 and the results are given in Fig.4.1. The number in Fig.4.1 corresponds to the question in Table 4.2. The questions on pond preparation practices are given in Table 4.10 (1,2 and 12).

Table 4.2 Awareness regarding pond preparation aspects

No.	Awareness Questions on Pond preparation(Yes/No)
1	Black soil is an indication of poor bottom soil quality
2	The bottom sludge should not be discharged into the water source
3	Ploughing on wet soil is the recommended practice
4	Black and toxic bottom sediments adversely affect shrimp health
5	Compaction avoids turbid water conditions during culture period
6	The optimum soil PH for shrimp culture should be above 6
7	Quick lime or hydrated lime is used only when the soil PH is <5
8	In acid sulfate soil, the lime is applied after filling the pond with water
9	Liming during pond preparation optimizes PH and alkalinity conditions of soil and water
10	There are recommended levels for lime application
11	The disinfectant is applied before the application of lime
12	The grow-out ponds should be filled at least 14 days before stocking
13	The optimum water depth in the pond should be 1.2m
14	Keeping in reservoirs improve the water quality

Cleaning the pond bottom is a very important pond preparation activity (MPEDA/NACA 2003). As per Fig.4.1, 93.04% of the respondents were aware that black soil is an indication of poor bottom soil quality. Even though 98.26% answered correctly that the bottom sludge should not be discharged into the water source, variations were noticed in actual practice. Some farmers do not care to remove the sludge unless there was a disease outbreak during the last crop, some of them carry out the sludge removal only partially, i.e, sludge from the top soil layer and the feeding areas only are removed. Manual as well as mechanical removal of sludge was in practice. Disposing the sludge away from the farm site was difficult for many farmers as the farms were clustered. In many cases, the bund was not wide enough to dig a trench along it. So they dispose the sludge on the bunds leaving a chance for the sludge to seep back to the farm during rains. 85.22% answered correctly that black and toxic bottom sediments adversely affect shrimp health. The sludge was removed mostly when the soil was dry. 41.74% did not know that ploughing on wet soil is the recommended practice. Tractors and tillers were used for ploughing. Ploughing exposes the black soil layers underneath the bottom soil to sunlight and atmospheric oxygen thereby allowing oxidation of the organic wastes. There was 100% compliance for the practice of examining the farm soil was for bad smell, black colour, benthic algae etc. With respect to the practice of drying the pond bottom before filling with water, full compliance was noticed in 68.69% cases, minor deviation in 23.48% cases, major deviation in 6.09% cases and non compliance in 1.74% cases. Few of them reported that they could not comply with it at times because they were hurrying to do the next crop or that it was not possible for them to drain the water completely because of the topography of the site. 65.22% answered correctly that compaction avoids turbid water conditions during culture period. Big wooden platforms and rollers were used for compaction.

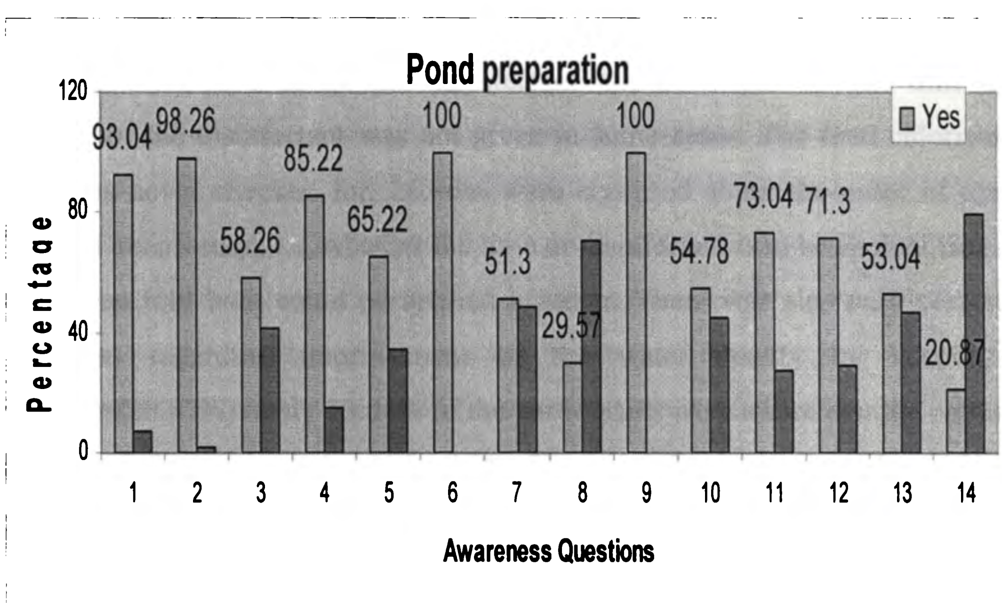

Fig 4.1 Awareness regarding Pond preparation aspects

Lime is widely used to neutralize acidity, increase total alkalinity and to increase total hardness in the soil and water of shrimp farms(100% compliance). Before the application of lime, the pH of the soil and water was checked and the type and amount of lime to be added was determined. The soil pH was measured by air drying some soil, adding to it an equal weight of fresh water, mixing and leaving overnight before measuring. pH indicator solutions were usually used. All were aware that the optimum soil pH for shrimp culture should be above 6. Everybody was using lime for obtaining the required pH. Quick lime and dolomite are used initially and finally respectively. There was 100% awareness that liming is for the maintenance of pH. But their knowledge on the type and quantity of lime used and application of disinfectant etc. was poor. 45.22% did not know there is proper guidelines on lime application and they were applying the lime in split doses and checking the pH each time after the application of lime and thereby obtaining the desired pH. There was also confusion regarding the selection of lime according to the soil pH. In case of acid sulfate soil, lime is to be added after filling the pond. Only 51.30% and 29.57% answered correctly that quick lime or hydrated lime is used only when the soil pH is <5 and in acid sulfate soil, the lime is applied after filling the pond with water respectively. Pond bottom sterilization knowledge was not high as some of them were unaware of the proper disinfection procedures. Bleaching powder (Calcium hypochlorite) was used as the disinfectant and sufficient contact time after addition of the disinfectant was not given in some cases. The final chlorination level was never checked for. 26.96% were confused about the order of use of lime and disinfectant, i.e, whether the lime or disinfectant is to be applied first and some even told both could be applied together. There was also only very little awareness regarding improvement of the water quality by keeping in reservoirs(20.87%). Only 53.04% of the participants were aware that the optimum water depth in the pond should be 1.2m. However, the answers received in other cases were 1-1.5m. 71.30% were aware that the grow-out ponds should be filled at least 14 days before stocking. The overall pond preparation knowledge of the farmers was satisfactory.

4.3.3.2 Fertilization

Fertilization is a standard practice during pond preparation to enhance production of natural food in ponds. Semi intensive type of culture systems which require a combination of fertilizer and supplemental feeding was followed in all the farms studied. The questions related to pond fertilization knowledge and practices are as in Table 4.3 (1-8) and Table 4.10 (3 and 4) respectively. The awareness percentage is given in Fig. 4.2.

Table 4.3 Awareness regarding fertilization aspects

No.	Awareness Questions on Fertilization (Yes/No)
1	The purpose of fertilization is to encourage the growth of green algae
2	Green algae reduces stress on PL and prevents growth of harmful benthic algae
3	Green water ponds have better production and lower risk of disease outbreaks
4	Mixed fertilization is the best method
5	Synthetic fertilizers result in sudden development and crash of bloom
6	Organic fertilizers like fresh cowdung may contaminate the pond water
7	Fertilizers if used indiscriminately can cause deterioration of soil and water conditions
8	Semi intensive culture systems require a combination of fertilizers and supplemental feeds

About 82.61% of them were aware that the purpose of fertilization is to encourage the growth of green algae. 70.43% of them had realized that green water ponds have better production and lower risk of disease outbreaks and that green algae reduces stress on PL and prevents growth of harmful benthic algae. Fertilization was done about ten days before stocking((full compliance 55.65%, minor deviation 31.30% and major deviation 13.05%). The farmers have studied from their experience that there is significant relation between disease outbreaks and algal populations within the pond. So the management measures needed to maintain a healthy algal bloom in the farm such as water exchange, proper water depth, nutrient management etc. were well adopted. If the bloom was very dense, water exchange was carried out and if there was a reduction in bloom due to heavy rain, excessive water exchange or other reasons, fertilization was done. The most commonly used natural fertilizer in

shrimp farms is cowdung. Supplemental doses were regularly added during the culture phase. However, there was only very little awareness regarding natural fertilizers like fresh cowdung that it may contaminate the pond water (38.26%). The synthetic fertilizers used were ammonium phosphate and urea and were applied by the broadcast method to enhance growth of natural food. With respect to the practice of using natural and synthetic fertilizers, full compliance was noticed in 89.56% cases and minor deviation in 10.44% cases. During later stages of culture, the addition of fertilizers was minimized as the farm gets nutrients from waste feed and shrimp excreta. The awareness on deterioration of soil and water conditions due to the indiscriminate use of fertilizers was 40.87% only. 80.87% of them agreed that mixed fertilization is the best method and it was known to 62.61% that synthetic fertilizers result in sudden development and crash of bloom. There was only very little awareness regarding different types of culture systems Only 12.17% could answer correctly that semi intensive culture systems require a combination of fertilizers and supplemental feeds.

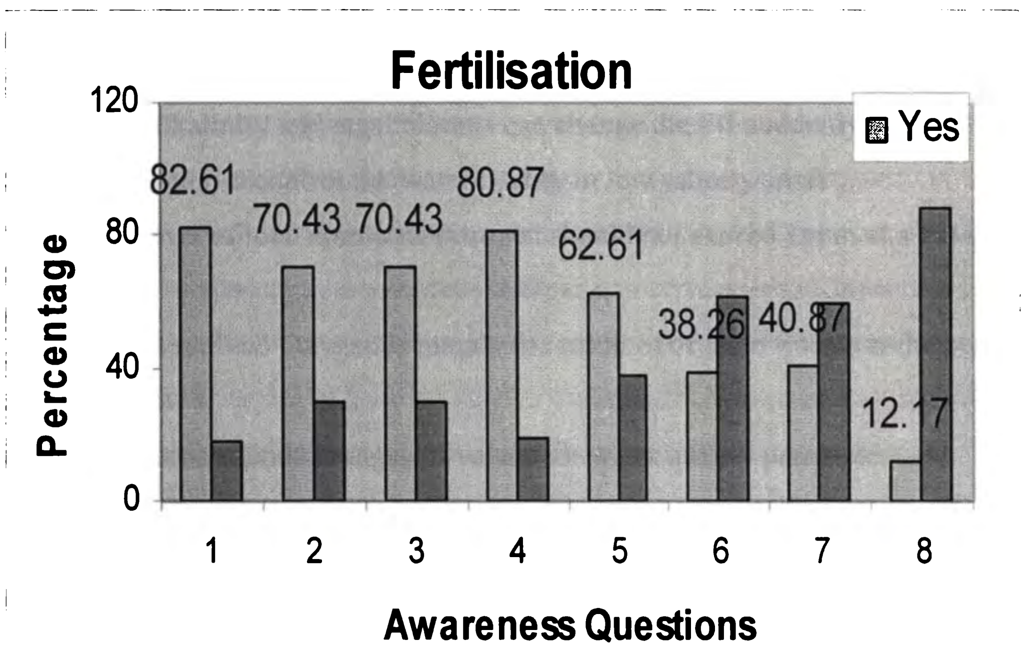

Fig 4.2 Awareness regarding fertilization aspects

4.3.3.3 Water and Soil Quality Management

There are reports that a number of risk factors that are related to shrimp disease outbreaks and shrimp production can be addressed through proper water quality management. Studies have proved that farms exchanging water, using aeration and filtering water with nets of fine mesh etc. to maintain water quality will yield better production. Maintenance of optimum salinity, pH and algal population etc. also has profound influence on shrimp production. The questions related to water and soil quality knowledge and practices are as in Table 4.4 (1-10) and table 4.10 (7,10,15, 23 and 24) respectively.

Table 4.4 Awareness regarding Water quality management aspects

No.	Awareness Questions on Water quality management (Yes/No)
1	The water depth in the shallowest part of the pond should be at least 80
2	cms
3	The ideal water exchange should be 10% of water in the pond
4	PH above 8.5 is not favorable for shrimp farming
5	Low alkalinity and algal blooms can change the PH suddenly
6	It is easier to control the water quality in low salinity areas
7	The level of total ammonia nitrogen should not exceed 1ppm at a PH of 8.5
8	Low dissolved Oxygen is mainly the result of organic wastes at the pond bottom
9	The recommended ranges of values for water quality parameters are known to me
10	The effluents containing chemical residues should not be discharged to natural water bodies
	Prophylactic treatments should be avoided due to the chance for development of antibacterial resistance

As per Fig.4.3, 80.87% answered correctly what can be the water depth in the shallowest part of the pond while it was known to 66.95% that the ideal water exchange should be 10% of water in the pond. 85.22% of them knew that pH above 8.5 is not favorable for shrimp farming. About 64.35% of them were aware that low Dissolved Oxygen is mainly the result of organic wastes at the pond bottom, yet very few (6.09%) of them knew the recommended ranges of values for water quality parameters. Dissolved oxygen levels were often not tested for, yet when the shrimp were seen to suffer from lack of oxygen, preventive measures were taken. With respect to the practice of following adequate water exchange, full compliance was noticed in 69.56% cases, minor deviation in 25.22% cases, major deviation in 1.74% cases and non compliance in 3.48% cases. But, 23.48% did not know that low alkalinity and algal blooms can change the pH suddenly. 54.78% of them had noticed the easiness in controlling the water quality in low salinity areas. Keeping the water in reservoirs with proper fertilization and disinfection reduces the problem of turbidity, fluctuations in algal bloom and chances for bacterial contamination and ensures supply of improved, uniform quality water throughout the culture period. The same water source was used for both, the intake and discharge of water. As per the recommended procedures, there should be one reservoir pond for every two grow-out ponds, if only one pond is there, one quarter of the pond should be converted into a reservoir with a water depth of at least 2 meters. Water should be stocked in the reservoir pond for at least 14 days before pumping to the culture ponds to facilitate the growth of plankton and to stabilize turbid and unstable water sources. But, this was never practiced in most of the farms studied (full compliance 5.21%, minor deviation 7.83%, major deviation 6.09% and non compliance 80.87%). Maintenance of reservoirs were not practical in some areas and even where it was possible people were found to use the reservoirs also as grow-out ponds. Filtration of water reduces the risk of entry of disease carriers, predators and competitors for shrimp. Filtered water was used in almost all the farms(full compliance 66.96 % and minor deviation 33.04 %). Water was filtered using a net of more than of 60 holes/sq. inch mesh at the water inlet point, foot valves and suction lines were covered and kept about half a foot above the pond bottom to avoid turbidity during the pumping process. Many of them(83.48%) did not know that the level of total ammonia nitrogen should not exceed 1ppm at a PH of 8.5. 63.48% agreed that the effluents containing chemical residues should not be discharged to natural water bodies, very few (20.87%) had awareness on the chance for development of antibacterial resistance consequent to the use of prophylactic treatments. The water quality parameters like salinity and pH were checked daily, but the practice of recording was very poor(full compliance 29.56%, minor deviation 53.04%, major deviation 14.78% and non compliance 2.62%).

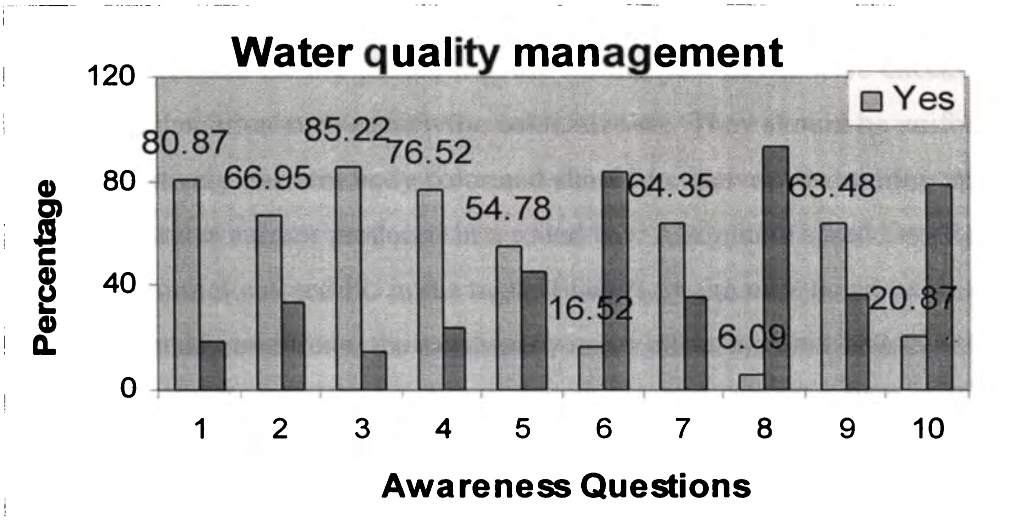

Fig 4.3 Awareness regarding Water quality management aspects

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Aeration was not carried out in any of the farms studied. The shrimp farmers need to check the important water quality parameters (pH, water transparency, water color, water temperature, alkalinity etc.) routinely, after each water exchange, several times after heavy rains and on daily basis. The percentage of compliance on the practice of sending water and shrimp samples to a recognized laboratory for testing the required physical, chemical and bacteriological parameters once in a crop cycle or at least once in a year was, full compliance 5.21%, minor deviation 19.13%, major deviation 37.39% and non compliance 38.27. Most of them were depending on the regular monitoring of water and shrimp quality conducted by the regulatory agencies.

4.3.3.4 Seed Quality and Stocking

The questions related to seed quality and stocking knowledge and practices are as in Table 4.5 (1-10) and Table 4.10 (5 and 6) respectively. About 86.09% of them opined that the quality of the seed is very important in shrimp culture. When 83.48% of them takes into consideration the price of the seed while purchasing, many of the farmers (59.13%) were of the complaint that they were not getting good quality seed. The farmers always attribute poor quality of seed for crop failures occurring within a fortnight after stocking. Some of them were purchasing PL from other states like Tamil Nadu and even when purchased from Kerala, they were obtaining nauplii brought from other states and reared in hatcheries in Kerala. Before purchasing, the shrimp post larvae were checked for their general condition such as activity, color, size etc. They should be uniform in size with relatively uniform body color and should be actively swimming against the swirling water current produced in a round tub. Also, there should not be any dead and abnormal colored PL in the tank. If the PL in the tank failed to meet the above mentioned conditions, the purchaser moves on to the next tank. Once the post larvae pass these gross visual examination tests, a 2 step PCR using 59 randomly selected post larvae from the selected tank was conducted. Using 59 post larvae will allow detection of WSSV at 5% or more prevalence level. If the sample passes the PCR test also, it was then ordered for packing and transportation to the farm for stocking. 85.22% answered correctly that good quality seed will be active and appear light gray to dark brown and black in colour with a clean shell which indicates that the animal is molting frequently and growing fast.

Table 4.5 Awareness regarding seed quality and stocking aspects

No.	Awareness Questions on Seed quality and stocking (Yes/No)
1	Good quality seed will be active and appear light gray to dark brown and black in colour with a clean shell
2	The quality of the seed is very important in shrimp culture
3	While purchasing the seed,the price is also taken into consideration

4	The quality of seed available is not satisfactory
5	The seed should be tested for WSSV before purchase
6	Transportation time of the seed from hatchery to farm should be <6hrs
7	There are recommended densities of seeds to be packed in transportation bags
8	The PL should be acclimatized to the pond water conditions at the hatchery itself
9	The formalin treatment is effective in reducing the external parasites and fouling
10	The ideal stocking density is 5-7 PL/m2

About 80.00% of them were aware that the seed should be tested for WSSV before purchase. With respect to the practice of purchasing the seed only after PCR testing, full compliance was noticed in 66.96% cases, minor deviation in 19.13% cases, major deviation in 9.56% cases and non compliance in 4.35% cases. Only 41.74% could answer correctly that the seed should be transported from the hatchery to the farm in <6hrs. Only few (32.17%) of them knew that there are recommended densities for seeds to be packed in transportation bags. The recommended densities of seed in transportation bags are as follows: (PL 15 = 1000-2000/Litre, PL 20 = 500-1000/Litre). About 65.23% of them were aware that the PL should be acclimatized to the pond water conditions at the hatchery itself. However, the PL was acclimatized to the farm water conditions before stocking (100% compliance). On reaching the farm site, the PL from the transportation bags were carefully transferred into plastic tub or tanks. While buying from nearby hatcheries, the acclimatization was done at the hatchery itself whereas when the seeds were purchased from far away places, the acclimatization was done at each one's farm site. Weak and dead PL were removed before stocking . A separation method employed for this involves stirring the water thereby concentrating and locating the dead and weak seeds at the center-bottom of the tank. The good PL are siphoned off using a plastic pipe from the upper portion leaving behind the dead and weak seeds. In some cases, the plastic bag containing the PL was put in a plastic tub containing the farm

water for 2-3 hours. Then the bag was opened and the Pl released into the tub. During this process, the PL were acclimatized to the pond water conditions like salinity, pH and temperature with gradual addition of farm water to the tank. The PL were then slowly released into the farm water. But their knowledge on the formalin treatment was limited(21.74%). Formalin treatment is effective in reducing the external parasites and fouling, but in Kerala, the formalin treatment before stocking was not prevalent. 60.00% did not know the ideal stocking density of PL/m2. Andhra Pradesh where more than 70% of the Indian shrimp production comes from mainly adopt improved traditional farming practice with low investment (USD1000 ha/crop) with an average stocking density of 25000 post larvae (PLs) per hectare (Subasinghe 2005).

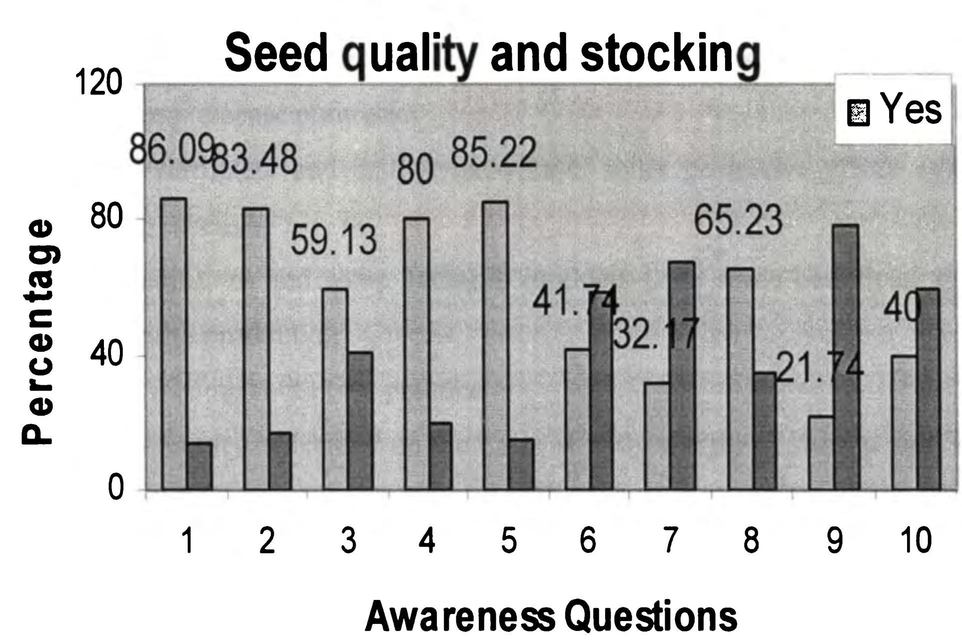

Fig 4.4 Awareness regarding seed quality and stocking aspects

4.3.3.5 Feed management

Feed management is an important aspect in shrimp farming operations. Good feeding practice is essential to maintain water and soil quality and a healthy environment within the pond. Feed trays were usually introduced after one week of stocking. The feeding area was changed at least once in ten days or as and when needed depending on the pond bottom condition along the feeding area. The feed size also was changed according to the growth and size of the shrimp. Three types of feeds were used; starter, grower and finisher. A mix of two feed pellet sizes were given for at least seven days before giving a higher pellet size feed. Check trays were also used to examine the general condition of the shrimp. The questions related to feed management knowledge and practices are as in Table 4.6 (1-8) and Table 4.10 (8,9 and 25) respectively.

Table 4.6 Awareness regarding feed management aspects

No.	Awareness Questions on Feed management (Yes/No)
1	The feeding area should be changed once in 10 days
2	Antibiotics and a range of probiotics have no significant effect on the risk of shrimp disease outbreaks
3	Lime, fertilizers and disinfectants have some protective effect against shrimp diseases
4	Feed additives and some bacterial products have some beneficial effect on shrimp production
5	Pellet feeding is the best practice
6	Meal quantity is decided on the basis of body weight of shrimp and feed tray results
7	Pesticides and antibiotics lead to residues in harvested shrimp
8	Fertilisers, lime, zeolite and related compounds do not lead to residues in harvested shrimp

It was known to 75.65% of them that the feeding area should be changed once in 10 days. With respect to the practice of following the feed tables supplied by the manufacturers, full compliance was noticed in 49.56% cases, minor deviation in 33.04% cases, major deviation in 7.83% cases and non compliance in 9.57% cases. Only 25.22% answered correctly that antibiotics and a range of probiotics have no significant effect on the risk of shrimp disease outbreaks. It was known to 55.65% only that lime, fertilizers and disinfectants have some protective effect against shrimp diseases. About 46.96% of them were aware that feed additives and some bacterial products have some beneficial effect on shrimp production. 74.78% of them opined that pellet feeding is the best practice. Majority of the farmers were following pellet feeding practice (full compliance 93.04 %, minor deviation 6.96%). Many of them were unable to monitor the quality of the feed on arrival due to lack of knowledge and expertise. 40.87% answered correctly that pesticides and antibiotics lead to residues in harvested shrimp. However, 39.13% did not know that fertilisers, lime, zeolite and related compounds do not lead to residues in harvested shrimp. Feed management becomes a still costly affair for the farmer when the harvesting is delayed on account of non availability of a buyer or reasonable prize. About 93.04% of them were aware that meal quantity is decided on the basis of body weight of shrimp and feed tray results. The feeding schedule followed by most of the farmers was based on check tray results during previous meal and body weight of the shrimp(full compliance 88.69%, minor deviation 11.31%).

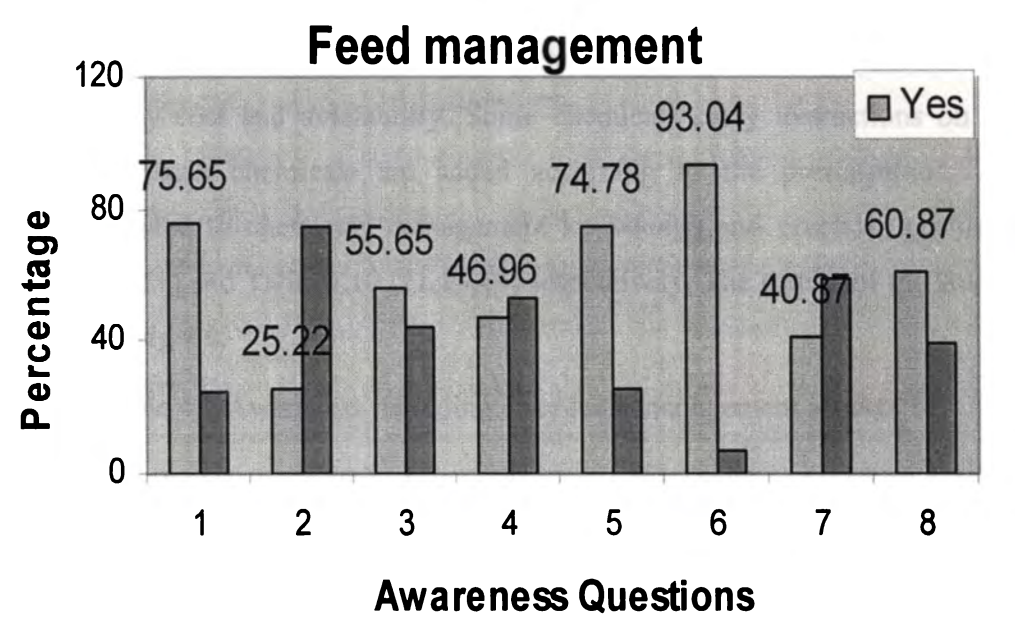

Fig 4.5 Awareness regarding Feed management aspects

4.3.3.6 Chemicals Management

Many chemicals are used as prophylaxis and against shrimp diseases without any beneficial effect. Farms with higher stocking densities as reported were found to use more chemicals, both in terms of number and the quantity applied. Calcium hypochlorite, lime, fertilizers like urea and superphosphate, zeolites, quaternary ammonium compounds like benzalkonium chloride (BKC), iodophores, Vitamin C, Copper sulphate etc. are the common chemicals used by the shrimp farming industry. Zeolites are tectosilicate minerals often applied to shrimp farms to remove ammonia. Quaternary ammonium compounds like benzalkonium chloride are used as bactericides and fungicides. Ammonia is used in shrimp culture as a piscicide prior to and during pond stocking. Vitamin C is widely used as a feed supplement as ascorbic acid deficiency shows moulting incompetence, malformation of carapace, disorder of gill and high mortality. Some chemicals and feed additives are found to have some beneficial effects on shrimp health, but none of them were found to be effective against shrimp disease occurrence. Even though a number of chemicals were used for various functions, most of them did not know the properties and proper dosage of such chemicals and often the chemical of choice was determined by cost and availability. Some chemicals carry instructions on the packets and such chemicals are added according to the prescriptions. The questions related to chemicals management knowledge and practices are as in Table 4.7 (1-17) and Table 4.10 (11,13,14) respectively. The results of the studies are given in Fig.4.6.

Table 4.7 Awareness regarding chemicals management aspects

No.	Awareness Questions on Chemicals Management (Yes/No)
1	Zeolites are tectosilicate minerals applied to shrimp ponds to remove ammonia
2	Chlorine decays with time by the action of sunlight and by use for oxidation of organic matter
3	Release of chlorinated water to the receiving water body can cause

	localized biological effects
4	Iodophores are widely used as disinfectants in shrimp farming
5	Quaternary ammonium compounds like BKC have detergent and antibacterial activity and are widely used as bactericides and
6	fungicides
	Use and ingestion of chloramphenicol in humans is associated with
7	aplastic anaemia
	The major environmental hazard of chloramphenicol is its potential
8	to increase drug resistance
9	Antibacterial agents like nitrofurans are potential carcinogens
10	The use of some drugs like chloramphenicol are banned in aquaculture
11	Malachite green is a respiratory enzyme poison and lengthy withdrawal period is needed following its application
	Tiger shrimp with ascorbic acid deficiency show moulting
12	incompetence, malformation of carapace, disorder of the gill and associated high mortality
13	Chemicals like astaxanthin if used during growth phase can cause artificial colouration of shrimp flesh
14	The importing countries have introduced residue monitoring programmes for aquaculture imports
15	When an animal is treated with any chemical either by bath, oral or via injection, the chemical will generally be absorbed by the animal
16	concerned
	MRL is the maximum concentration of residue resulting from the use of a drug that is recognized as acceptable in food
17	Withdrawal period is the time delay between cessation of therapy and harvesting
	There is potential for some chemical compounds used in aquaculture to pose health risks to farm workers

It was known to 32.17% that zeolites are tectosilicate minerals applied to shrimp ponds to remove ammonia. 87.83% did not know that chlorine decays with time by the action of sunlight and by use for oxidation of organic matter. 36.52% were aware that release of chlorinated water to the receiving water body can cause localized biological effects. It was known to 23.48% that iodophores are widely used as disinfectants in shrimp farming. There was only 25.22% awareness that Quaternary ammonium compounds like BKC have detergent and antibacterial activity and are widely used as bactericides and fungicides. There was 100% awareness regarding the ban on certain drugs like chloramphenicol in aquaculture. However, the reason behind such bans was poorly understood. Only 18.26% answered correctly that the major environmental hazard of chloramphenicol is its potential to increase drug resistance. Only 2.61% were aware that the use and ingestion of chloramphenicol in humans is associated with aplastic anaemia. It was known to 22.615 only that antibacterial agents like nitrofurans are potential carcinogens. 41.74% answered correctly that malachite green is a respiratory enzyme poison and lengthy withdrawal period is needed following its application. It was known to 60.00% of the farmers that ascorbic acid deficiency show moulting incompetence, malformation of carapace, disorder of the gill and associated high mortality in Tiger shrimp. About 21.74% of them knew that chemicals like astaxanthin if used during growth phase can cause artificial coloration of shrimp flesh. 26.96% did not know that the importing countries have introduced residue monitoring programmes for aquaculture imports. 66.96% of them knew that when an animal is treated with any chemical either by bath, oral or via injection, the chemical will generally be absorbed by the animal concerned. There was only very little awareness regarding maximum residual level (MRL) and withdrawal period. Only 36.52% and 35.65% answered correctly that MRL is the maximum concentration of residue resulting from the use of a drug that is recognized as acceptable in food and withdrawal period is the time delay between cessation of therapy and harvesting respectively. It was known to 59.13% that there is potential for some chemical compounds used in aquaculture to pose health risks to farm workers (59%). Just like many other countries engaged in coastal aquaculture, we also have few or no regulatory controls and little documentation of the chemicals used by the industry.

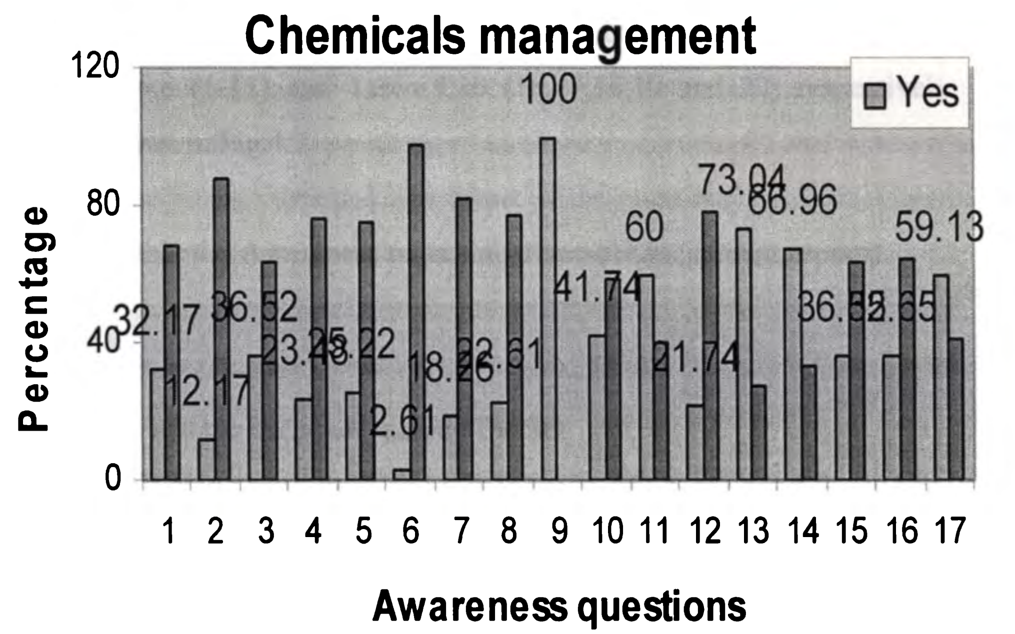

Fig 4.6 Awareness regarding chemicals management aspects

Chloramphenicol and nitrofurans are banned for use in shrimp aquaculture. Even though banned, enforcement of such bans is weak. However, compliance regarding non use of antibiotics was 100%. Studies have clearly shown that shrimps of good quality can be grown with very minimal chemical usage and without the usage of antibiotics. Such methods lead to reduced cost of production and easy marketability of the harvested shrimp. There was 100% compliance on the use of chemicals and fertilizers as and when needed. In some areas, farmers were using probiotics and maintaining minimum water exchange (full compliance 9.56%, minor deviation 6.09%, major deviation 15.65% and non compliance in 68.70%). There was widespread prophylactic use of antibacterial agents especially in Kollam district mainly because of the influence of the local feed suppliers. Antibiotics were not used knowingly and directly, but nobody was in the habit of testing the feeds before use. However, the farmers try to avoid using chemicals except those unavoidable, about two weeks before harvesting.

4.3.3.7 Shrimp Health and Disease Management

Vibriosis, loose shell, Monodon Baculo Virus, White Spot Syndrome Virus etc. are the major disease problems faced by the farmers. The questions related to health and disease management knowledge and practices are as in Table 4.8 (1-11) and Table 4.10 (16,17,18,19 and 23) respectively. The results are given in Fig.4.7.

Table 4.8 Awareness regarding disease management aspects

No.	Awareness Questions on Disease management (Yes/No)
1	WSSV is the necessary cause of WSD
2	WSSV alone can't bring out a WSD outbreak in the pond
3	WSSV can enter the shrimp and the pond through different routes
4	Good pond management practices can reduce the risks of WSD
5	There is some relation between WSSV and temperature
6	Viral diseases like WSD can't be treated by antibiotics
7	Vibriosis called 'one month mortality syndrome' is caused by vibrios
8	Loose shell syndrome is a bacterial infection
9	HPV attacking the hepatopancrease of shrimp will cause slow or stunted growth
10	Appearance of any sick shrimp in any of the surrounding farms is an indication of stressful condition in the area.
11	The infected pond should be disinfected before discharging the water

The awareness with respect to the question on the virus responsible for causing white spot disease (WSD) was 86.09%. Studies have proved that WSSV alone can't bring out a WSD outbreak in the pond. 72.17% of them were not aware of this fact. 61.74% did not agree that good pond management practices can reduce the risks of WSD. This again points to their experience that bad quality seeds can bring in the viral disease. It was known to 49.56% that the WSSV can enter the shrimp and the pond through different routes. The uneffectiveness of antibiotics in treating viral diseases like WSD was not known to 75.65% of the farmers. 55.65% of them noticed some relation between WSSV outbreak and farm water temperature. 15.65% answered correctly that vibrios are the causative agents of Vibriosis. 20.87% knew about the loose shell syndrome and only 1.74% answered correctly about the symptoms of Hepatopancreatic virus (HPV) attack. Most of them answered correctly that sudden changes in the color of pond water, weather conditions, blackening of pond bottom, Shrimp coming to the edges of the pond etc. are all bad symptoms and should be seriously viewed and acted. 89.56% of them knew that the appearance of any sick shrimp in any of the surrounding farms is an indication of stressful condition in the area However, the information towards isolation and disinfection of the infected ponds before discharging the water was 68.69% only.

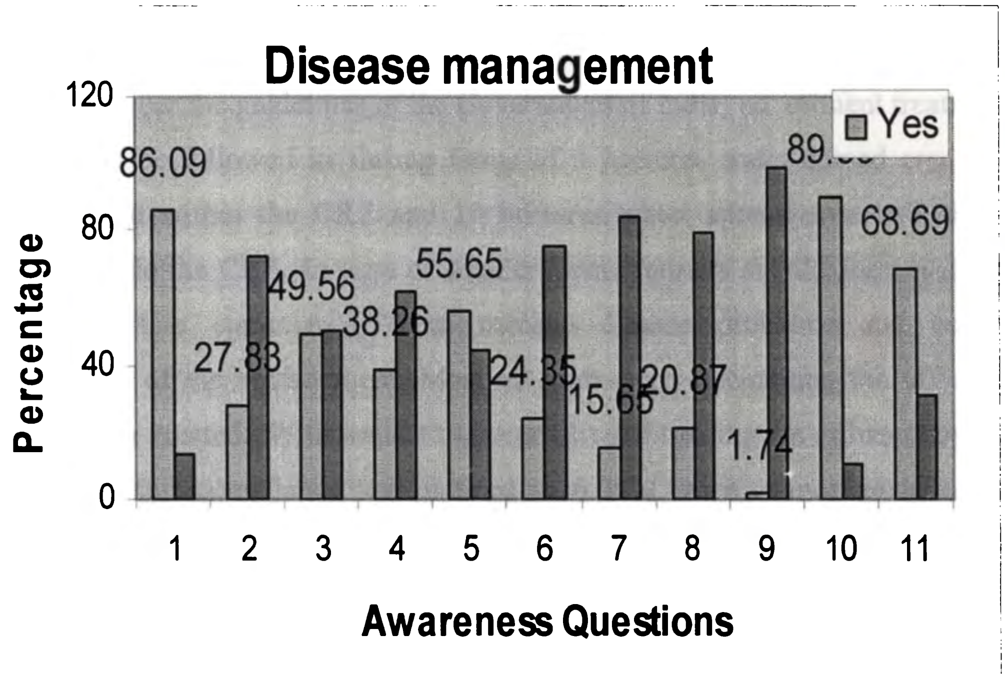

Fig 4.7 Awareness regarding disease management aspects

Farmers still suffer disease problems in spite of all the precautions. If dead shrimps appear, in such cases, the dead animals are removed and buried away from the pond site(full compliance 40.87%, minor deviation 53.04% and major deviation 6.09%). If the mortality rate further increases rapidly and shrimp were not feeding, an emergency harvest was carried out using cast net to avoid discharge of infected water into the main water source. The practice of isolating the pond, informing the neighbors and disinfecting the water before discharging if disease occurs, was prevalent in 74.78% cases (full compliance), 9.57% cases (minor deviation), 11.31% cases (major deviation) and 4.34% cases (non compliance). The pond water should be treated with bleaching powder and left for 5-7 days before discharging the water to the drainage. Prompt action is essential in such occasions to rectify the problems, reduce the losses and minimize the impact on neighboring farms. Most of the farmers try to avoid water exchange during such periods and do not use equipments like nets, tanks, pumps, boat and other utensils which were used in the affected farms. To maintain water quality during such periods, feeding was also reduced to compensate for the reduced water exchange. In some places where some disputes exist, farmers told that they do not inform the neighbors when they get disease problems. Encouragement of formation of shrimp farmer's cooperative organizations is a best solution to such problems. As per the guidelines of the Government of India, an effluent treatment system must be followed in shrimp farms of 5 hectares water spread area and above located within the CRZ and 10 hectares water spread area and above located outside the CRZ. In case of smaller farms farmers should form a group and construct a common ETS to manage disease problems and ensure sustainability of the environment. Most of them were discharging the effluents without being treated. With respect to the practice of treating the effluents before discharging, full compliance was noticed in 6.08% cases, minor deviation in 7.83% cases, major deviation in 13.04% cases and non compliance in 73.04 % cases.

Shrimps should be sampled once in a week by cast netting and checked for their health condition like external appearance-body color, missing appendages, external fouling, gill fouling, black gills or gill choking , gut condition and growth in terms of weight or length. 100% compliance was observed for this practice. Feeding check trays were also used to examine the general condition of the shrimp. Shrimp behavior and feeding trends should be monitored and properly recorded. Even though the compliance regarding monitoring of shrimp health was 100%, the compliance regarding recording the results for current reference and future use was very poor. In fact, a 4 years old active shrimp farmer could easily identify and rectify the minor problems without referring to the previous data. The first sign of disease was when weak or diseased shrimps swim at the water surface or coming to the edges of the pond. During such periods, looking back at the farm records for sharp changes in the water quality, bottom soil conditions or appearance of shrimp in cast net sampling and feeding trays will give an idea on the possible causes of disease. Many farmers depend on a successful crop to be able to ensure livelihood of their households. So success in each crop and every crop was their objective which made them understand everything by heart. Regular monitoring and review of important parameters can rectify the problems at an early stage and thus prevent the occurrence or spread of disease. The risk of disease in shrimp farming often increases with culture intensity and high stocking densities, and when polyculture is replaced by monoculture. High pond densities will facilitate the spread of pathogens between ponds (Kautsky et al. 2000). Reddy et al. (2007) noted that reduced stocking density and disease identification techniques like keeping at least a minimum gap between two crops helped in reducing the diseases and infections.

4.3.3.8 Harvesting and post harvest handling

Table 4.9 Awareness regarding harvesting and post harvest handling aspects

No.	Awareness Questions on Harvesting and post harvest handling (Yes/No)
1	The shrimp to ice ratio should be 1:1
2	Potable water and ice made out of potable water should be used for washing and icing the catch
3	The time lag between harvest and icing should be kept to the minimum
4	The harvested shrimp should be kept at or below 50c
5	Uncleaned utensils and food contact surfaces can contaminate the harvested shrimp
6	Workers suffering from ulcers and other contagious diseases should be restricted from handling the raw material

7	All operations after harvesting should be in a sanitary manner to prevent contamination with filth
8	The raw material should be kept safe from the reach of pests and domestic animals
9	Usage of chlorinated water leads to reduction in bacterial load
10	Metabisulphite treatment is effective in preventing black spot formation in shrimp

The questions related to post harvest handling knowledge and practices are as in Table 4.9 (1-10) and Table 4.10 (20 and 21) respectively. The harvesting was usually carried out using cast nets, long nets and finally by hand picking. Techniques in harvesting shrimp by hand picking and other methods in shrimp farms have been described (Pravin and Ravindran 2005). Harvested shrimp was put in large bamboo baskets or plastic crates hired for the purpose and sometimes kept on the floors of car sheds temporarily converted for the purpose of sorting and grading in the case of farmers who had farms near their houses. It was known to 87.83% that the time lag between harvest and icing should be kept to the minimum. However, only 46.96% were aware that the shrimp to ice ratio should be 1:1. 54.78% of the respondents were aware of the importance of using potable water and ice made out of potable water for washing and icing the catch. It was known to 74.78% that the harvested shrimp should be kept at or below 5^0c. There was often no timing of how long the shrimp was left at ambient temperature after harvesting. Shrimp being left for over 8hours, overnight and in some instances even until the end of the harvest. The shrimp after harvest was immediately washed and iced (full compliance 20.87%, minor deviation 45.22% and major deviation33.91%). Ice was not properly crushed as well as the ice was stored on the floor covered with cotton sacks, in some cases. Many had a poor knowledge of cleaning and disinfection procedures. This included being unaware of the importance of use of chlorine and other cleaning and disinfection procedures. 71.30% could answer correctly that uncleaned utensils and food contact surfaces can contaminate the harvested shrimp. With respect to the practice of properly disinfecting the basins and other utensils before use, full compliance was noticed in 6.09% cases, minor deviation in 14.78% cases, major deviation in 31.30% cases and non compliance in 47.83% cases. There was also only very little awareness (29.56%) regarding preventing workers suffering from ulcers and other contagious diseases from handling the raw material. However in instances where the crop was sold to reputed seafood processing units, the harvesting and post harvest handling were under their supervision and in such cases the material was kept in excellent condition. 59.13% of them knew that all operations after harvesting should be done in a sanitary manner to prevent contamination with filth. Everybody (100%) agreed on the point that the raw material should be kept safe from the reach of pests and domestic animals. 59.13% did not know that the usage of chlorinated water leads to reduction in bacterial load. The significance of metabisulphite treatment in preventing black spot formation in shrimp was also not familiar to many (60.87%). Those who were aware of the significance of metabisulphite treatment, was keeping the harvested shrimp in ice only after carrying out the metabisulphite dip treatment. Reports on the incidence of V. parahaemolyticus in shrimp environments in India suggests a probable risk for health of people consuming raw seafood. Therfore, it is recommended to pay attention to post-harvest handling and adequate cooking to safeguard public health (Spaargaren 1997).

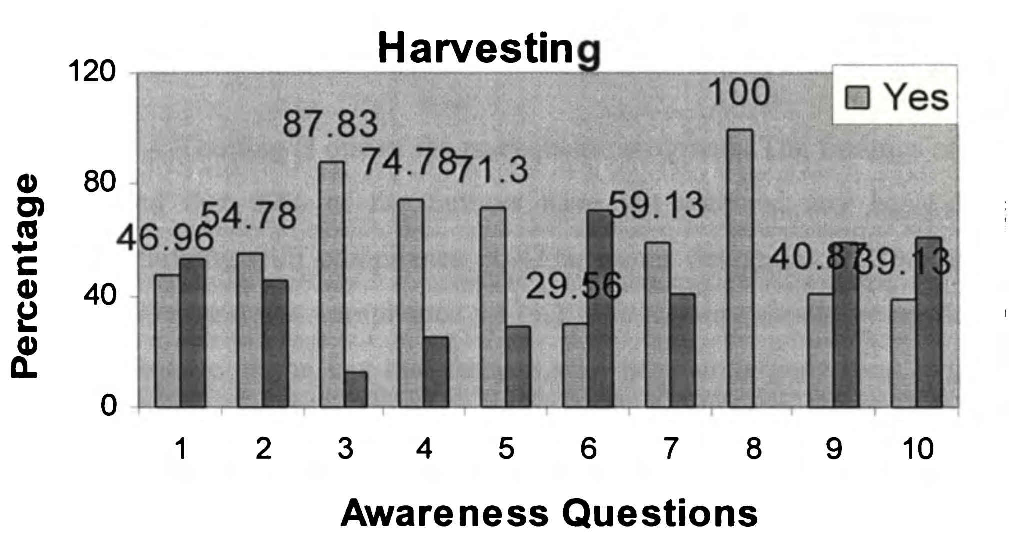

Fig 4.8 Awareness regarding harvesting and post harvest handling aspects

4.3.3.9 Record Keeping and Training

The questions related to record keeping and training aspects are as in Table 4.10 (22,26 and 27). Maintenance of farm management records is a good practice. Records are necessary to review the sequence of changes in water and soil conditions, feeding, overall shrimp health and the management practices followed and identify the problems in the pond environment and shrimp health and to rectify these problems at the earliest during the production cycle. Record keeping helps the farmers to learn from past mistakes, thus reducing risks and cost of production in subsequent crops. Records are helpful to plan the entire crop cycle including stocking densities and the expected expenditure for each pond well in advance. These records should contain details on pond preparation, seed and its stocking, feed management, water quality parameters and its management, pond bottom management, shrimp health and harvest etc. With regular monitoring and review of important parameters it is easier to understand and rectify the environmental conditions at an early stage and prevent the occurrence or spread of disease to other shrimps. With respect to the practice of proper documentation, full compliance was noticed in 3.48% cases, minor deviation in 15.65% cases, major deviation in 21.74% cases and non compliance in 59.13% cases. Even those who are recording it, is writing it either in a note book to show the farm manager, or at the backside of the delivery notes just for a week or the particular season's reference. In almost all the cases such notes were not presentable and could not be considered as a document.

Training is one of the prerequisite programs. The findings of this study indicated that 50% of the farmers have not received any basic farm management training (full compliance 30.43%, minor deviation 38.27%, major deviation 21.73% and non compliance 9.57%). The training should be a priority for farmers because of the fact that farmers who have undergone food hygiene training will use more appropriate farm safety practices. The success of a HACCP program depends on the education and training of the employees on the importance of their role in maintaining farm safety (Bas et al. 2006). Majority of the farmers did not possess any literature or guidelines on good aquacultural practices(full compliance 3.48%, minor deviation 5.21%, major deviation 16.53% and non compliance 74.78%). The farmers need be supplied with performance standards, personal hygiene rules, cleaning and disinfection procedures etc.

Table 4.10 Selected items of HACCP prerequisite programs practices

Observed practices	Full C %(No.)	Min D %(No.)	Maj D %(No.)	Non C %(No.)
1. The pond bottom is dried for about two weeks before filling with water	68.69(79)	23.48(27)	6.09(7)	1.74(2)
2. Lime is added to adjust the pH	100.00	0.00	0.00	0.00
3. Fertilisation is done about ten days before stocking	55.65(64)	31.30(36)	13.05(15)	0.00
4. Natural as well as synthetic fertilizers are used	89.56(103)	10.44(12)	0.00	0.00
5. The seed is purchased only after PCR testing	66.96(77)	19.13(22)	9.56(11)	4.35(5)
6. The PL is acclimatized to the farm water conditions before stocking	100.00	0.00	0.00	0.00
7. Salinity and pH are checked daily and recorded	29.56(34)	53.04(61)	14.78(17)	2.62(3)
8. The feed quantity is decided based on checktray results and body weight of shrimp	88.69(102)	11.31(13)	0.00	0.00
9. The feed tables supplied by the manufacturers is being followed	49.56(57)	33.04(38)	7.83(9)	9.57(11)
10. Adequate water exchange is followed	69.56(80)	25.22(29)	1.74(2)	3.48(4)
11. Use probiotics and maintain minimum water exchange	9.56(11)	6.09(7)	15.65(18)	68.70(79)
12. The farm soil is examined for bad smell, black color, benthic algae etc.	100.00	0.00	0.00	0.00
13. Zeolite, BKC and fertilizers are used as and when needed	100.00	0.00	0.00	0.00
14. Antibiotics are not used	100.00	0.00	0.00	0.00
15. Send water and shrimp samples to a laboratory for testing	5.21(6)	19.13(22)	37.39(43)	38.27(44)
16. Shrimps are sampled once in a week by cast netting and checked for their health condition	100.00	0.00	0.00	0.00
17. The dead animals are removed and buried away from the pond site.	40.87(47)	53.04(61)	6.09 (7)	0.00
18. The effluents are treated before	6.08(7)	7.83(9)	13.04(15)	(5)

discharging				
19. The pond is isolated, neighbors informed and the water disinfected before discharging if disease occurs	74.78(86)	9.57(11)	11.31(13)	0.00
20. The shrimp after harvest is immediately washed and iced	20.87(24)	45.22(52)	33.91(39)	0.00
21. The basins and other utensils used are properly disinfected before use	6.09(7)	14.78(17)	31.30(36)	55(47.83)
22. Proper records are maintained	3.48(4)	15.65(18)	21.74(25)	59.13(68)
23. Reservoirs are maintained	5.21 (6)	7.83 (9)	6.09 (7)	80.87(93)
24. Filtered water is used	66.96 (77)	33.04(38)	0.00 (0)	0.00 (0)
25. Pellet feeds are given	93.04(107)	6.96(8)	0.00 (0)	0.00 (0)
26. Attended training in GAP	30.43(35)	38.27(44)	21.73(25)	9.57(11)
27. Guidelines on good aquacultural practices are available	3.48(4)	5.21(6)	16.53(19)	74.78(86)

Full C - Full Compliance, Min D - Minimum Deviation

Maj D – Major Deviation, Non C - Non Compliance

4.3.3.10 Areas of Poor Knowledge

Table 4.11 Areas of Poor Knowledge of the Shrimp Farmers

	Awareness Questions	**Yes (%)**	**No. (%)**
1.	In acid sulfate soil, the lime is applied after filling the pond with water	29.57	70.43
2.	Keeping in reservoirs improve the water quality	20.87	79.13
3.	Semi intensive culture systems require a combination of fertilizers and supplemental feeds	12.17	87.83
4.	The level of total ammonia nitrogen should not exceed 1ppm at a PH of 8.5	16.52	83.48
5.	The recommended ranges of values for water quality parameters are known to me	6.09	93.91
6.	Prophylactic treatments should be avoided due to the chance for development of antibacterial resistance	20.87	79.13
7.	The formalin treatment is effective in reducing the	21.74	78.26

	external parasites and fouling		
8.	Antibiotics and a range of probiotics have no significant effect on the risk of shrimp diseae outbreaks	25.22	74.78
9.	Chlorine decays with time by the action of sunlight and by use for oxidation of organic matter	12.17	87.83
10.	Iodophores are widely used as disinfectants in shrimp farming	23.48	76.52
11.	Quaternary ammonium compounds like BKC have detergent and antibacterial activity and are widely used as bactericides and fungicides	25.22	74.78
12.	Use and ingestion of chloramphenicol in humans is associated with aplastic anaemia	2.61	97.39
13.	The major environmental hazard of chloramphenicol is its potential to increase drug resistance	18.26	81.74
14.	Antibacterial agents like nitrofurans are potential carcinogens	22.61	77.39
15.	Chemicals like astaxanthin if used during growth phase can cause artificial colouration of shrimp flesh	21.74	78.26
16.	WSSV alone can't bring out a WSD outbreak in the pond		
17.	Viral diseases like WSD can't be treated by antibiotics	27.83	72.17
18.	Vibriosis called 'one month mortality syndrome' is caused by vibrios	24.35	75.65
19.	Loose shell syndrome is a bacterial infection		
20.	HPV attacking the hepatopancrease of shrimp will cause slow or stunted growth	15.65	84.35
21.	Workers suffering from ulcers and other contagious	20.87	79.13
	diseases should be restricted from handling the raw	1.74	98.26
	material	29.56	70.44

It is evident from Table 4.11 that the shrimp farmers do not have sufficient knowledge or information in certain areas. The awareness questions which scored below 30% are those relating to the application of lime in acid sulfate soil, importance of maintaining the reservoirs, formalin stocking, the effect of antibiotics and probiotics on the risk outbreaks, use of iodophores, BKC, nitrofurans etc. The knowle WSD outbreak, effectiveness of antibiotics in treating Viral diseases in and the possibility for contamination from workers suffering from ulcers and other contagious diseases etc. were also poor. The awareness questions which scored 20% and below were about the nature of semi intensive culture systems, level of total ammonia nitrogen at a P^H of 8.5, aftereffects of prophylactic treatments, disintegration of chlorine, environmental hazard of using chloramphenicol, causative agents of Vibriosis, loose shell syndrome etc. The awareness questions which scored 10% and below were regarding the recommended ranges of values for water quality parameters for shrimp farming, the health hazard arising from the ingestion of chloramphenicol and associated ill effects in humans, symptoms of HPV attack of shrimp etc. Therefore, during the survey, through small discussions the recommended practices were informed to the farmers.

4.3.3.11 Areas of Poor Practice

Table 4.12 Areas of Poor Practice and observation

Observed practices	Full C %	Min D %	Maj D %	Non C %
1. Use probiotics and maintain minimum water exchange	9.56	6.09	15.65	68.70
2. Send water and shrimp samples to a laboratory for testing	5.21	19.13	37.39	38.27
3. The effluents are treated before discharging	6.08	7.83	13.04	73.04
4. The shrimp after harvest is immediately washed and iced	20.87	45.22	33.91	0.00
5. The basins and other utensils used are properly disinfected before use	6.09	14.78	31.30	47.83
6. Proper records are maintained				
7. Reservoirs are maintained	3.48	15.65	21.74	59.13
8. Guidelines on good aquacultural	5.21	7.83	6.09	80.87

practices are availabe	3.48	5.21	6.53	74.78

Table 4.12 shows the areas of poor practice. Sending water and shrimp samples for testing in recognized laboratories, treating the effluents before discharging, proper water exchange, post harvest handling, record keeping, maintaining reservoirs, possession of literature on good aquacultural practices etc. are the practices which are not complied with properly. It is evident from table 3.4 that the practices such as post harvest handling, effluents discharging, the quality of influent water etc. are to be improved. Areas of improvement also include increased documentation of farm safety practices including recording of water and soil quality parametrs, details of seed and feeding, monitoring and health condition of shrimp, use of certified feed and chemicals, culture period etc. Documentation is needed to substantiate that appropriate growing and handling practices are occurring in shrimp farming operations in our state because operations that are documenting practices as part of prerequisite programmes are more likely to build effective HACCP systems. There is also the need for supplying the farmers with necessary literature at least the basic Guidelines on good aquacultural practices.

4.3.4 Assessment of PRP Attitude

The study on PRP awareness and practices indicated that proper PRPs- GAP/BMP for HACCP were often followed in most of the shrimp farms studied. However, the PRP attitude test was conducted to test the confidence, sense of responsibility, believes and expectations of the farmers. Majority of the farmers (75.66%) had not responded in the HACCP attitude test. The method described by Henroid and Sneed (2004) was followed for the PRP attitude study. Unfortunately, to most of the questions the attitude of the farmers was almost neutral. Table 4.13 shows that the mean attitude scores ranged from 3.13 to 4.27. This may be because they do not have sufficient exposure to international and national quality standards, global aquacultural practices, any manual or literature on good aquacultural practices and that they are unable to evaluate their own performance or standard. However, the highest score 4.27 obtained for the question on whether the food they are producing could cause human health hazards, if not properly raised is a clear indication that they are food safety conscious, responsible shrimp farmers.

Table 4.13 PRP attitude of the shrimp farmers

Statements	Scale	mean	sd
I am following good aquacultural practices	SA A	3.93	0.69
I am responsible for making sure that the effluents discharged from my pond does not harm the aquatic environment	N D SD	3.87	0.57
I believe that the food I am producing can cause human health hazards, if not properly raised		4.27	0.52
I would like to be trained in GAP which I think would help me to do my job better		3.73	0.83
The implementation of HACCP is needed in Indian aquaculture		3.13	0.51

SA-Stronglyagree(5),A-Agree(4), N-Neutral(3), D-Disagree(2), SD- Strongly disagree(1)

Henroid and Sneed (2004) found that the mean attitude scores ranged from 4.2 to 4.8 and the overall employee attitude towards food safety was favorable in school foodservice operations in Iowa. S!anchez and Muir (2003) studied the attitude of fishermen towards resources management and aquaculture development in Mexico and found that even though aquaculture was perceived strongly as an income and employment generation activity by 78.6% of the respondents, there was 55.8% disagreement on the technical assistance available and 55.2% disagreement on the involvement of government agencies in conflict solving.

4.3.5 Major Constraints faced by the Shrimp Farmers

The shrimp farmers who were selected for the HACCP and PRP study were contacted and asked to list and rank the problems faced by them according to the level of severity. Based on the responses the rank based quotient (RBQ) was calculated using standard procedures (Hogg and Craig 1995). RBQ is the weighted mean of ranks (1-worst to 10-best) with respective frequencies/ total frequency as weights. RBQ= sum(rank(i) * frequency of ith rank)/total frequency).

Table 4.14 Rank based quotients of major constraints in Shrimp farming

S.L.No	Major constraints	RBQ
1	Non availability of good quality seed	0.85
2	Low selling price	0.83
3	Non availability of a package for treating diseases	0.80
4	Need for risk coverage	0.76
5	Water quality monitoring by regulatory officials	0.71
6	Non availability of certified feed and high cost	0.70
7	Environmental pollution	0.60
8	Non awareness to quality norms and standards	0.56

The rank based quotient scores on the major constraints in shrimp farming are given in Table 4.14. As per Table 4.14, non availability of good quality seed, low selling price, non availability of a package for treating diseases, need for risk coverage, water quality monitoring by regulatory officials, non availability of certified feed, environmental pollution and non awareness to quality norms and standards etc. are the problems or requirements identified as key issues. RBQ analysis of the major problems faced revealed that non availability of good quality seed was the most important problem faced by the farmers which showed a score of 0.85. Wild-caught broodstock forms the only source of shrimp seed even today. At present, since most of the hatcheries are air lifting nauplii from neighbouring states on account of the high price and non availability of spawners in our coast, the quality of the spawners and even nauplii cannot be ensured. The most essential approach in shrimp culture seems to be production of better quality PL for pond release and the farmers regard PL survival rates as critical to their economic viability. Studies show that it is the smaller and weak PL which are more susceptible to Vibriosis, viral and other attacks. Shrimp production in hatcheries is a capital intensive process and many hatchery managers are observed to manipulate the quality of feed to compensate for the low selling price. Good nutrition of the early PL with diets containing optimum levels of vitamins, fatty acids and minerals is therefore assessed as central and there is need for ensuring the nutrition of hatchery reared larvae.

It is evident from Table 4.14 that low selling price was the second important problem faced by the farmers with a rank value of 0.83. The antidumping duty on Indian shrimp exports to US had a direct bearing on the resultant low selling price which had been raised from 10.17% to 10.54% recently (Anon 2007). As per the analysis non availability of a package for treating diseases scored a value of 0.80. This calls for more research and extension in this area. Need for risk coverage scored 0.76 and the increasing number of crop failures due to disease outbreaks indicates the need for crop insurance. Requirement for water quality monitoring by regulatory officials as per the analysis showed a value of 0.71. Water quality monitoring by regulatory officials at present in practice is unable to cover all the farms, the monitoring is limited to one or two farms or the main intake water source in an area. The test results are not communicated to the farmers. They request that the water quality should be checked by the regulatory officials and the water quality status and control measures need be informed or made available to them. High cost and non availability of certified feed which had an RBQ value of 0.70 was an important problem in this field. The choice of the feed often depends on various factors such as cost, availability and credit facilities offered. Several workers have studied the impact of feeding on growth, health and survival of the shrimp (Trifio and Sarroza

1995, Spaargaren 1997, Smith et al. 2002, Neori et al. 2004). The vitamin and mineral supplements incorporated in commercial feeds used in modified extensive culture systems can account for 20 to 23% of the total feed cost (Trifio and Sarroza 1995). Shrimp are generally omnivorous species. The composition of the food can be selected by considering local availability and costs but should meet their nutritional requirements (Spaargaren 1997). Feed accounts for about half the cost in current high-volume fed mono-species aquaculture, mainly shrimp ponds, yet most of this feed becomes waste (Neori et al. 2004). The feed should be nutritionally adequate, water stable and the feeding strategy contribute to the profitability of production and to the environmental impact of shrimp farming (Smith et al. 2002). Environmental pollution (0.60) was not a general problem, but it was noticed erratically in isolated places. The intake water was polluted due to contamination with fertilizers, pesticides, bacteria of sanitary significance, other activities like coconut husk decaying etc. Non awareness to quality norms and standards which scored 0.56 was the most common but not a major problem. Lekshmi et al. (2005) found most of the shrimp farmers of Nagapattinam (70.00%) had a medium level of extension contact, 68.33% had a medium level of risk orientation, followed by 93.33% with a medium level of credit orientation. Among shrimp farmers of Nellore, 57.50% had a medium level of extension contact, 55.83% had a medium level of economic motivation and 84.17% had a medium level of credit orientation.

4.4 Discussion

In the present study, the shrimp farmers were found to have a significant amount of knowledge in areas such as pond preparation, water and soil quality management, feed management etc. But their knowledge in other areas such as chemicals management, shrimp health management, disease management etc. was very poor. They were also found to be careless in certain areas such as post harvest handling and proper documentation. Pond preparation practices like sludge removal, ploughing, drying, liming and pond filling etc. being followed in the farms studied were satisfactory. However, pond bottom sterilization practices were found improper as they were not following specific guidelines and some of them were unaware of the presence of proper guidelines. Studies by Lekshmi et al. (2005) found the adoption behavior of shrimp farmers of Nellore in Andhra Pradesh and Nagapattinam in Tamil Nadu, high with respect to practices such as pond bottom conditioning, pond bottom sterilization, acclimatization and stocking of fry, liming of pond, feed management, health management and harvesting. Kumaran et al. (2001) reported that cent percent of the shrimp farmers had adopted good pond preparation, stocking of disease free hatchery produced seed and pellet feeding practices as a prerequisite for successful culture. In the present study, semi intensive type of culture system which require a combination of fertilizer and supplemental feeding was adopted in the farms studied. Hence good feeding practice is essential to maintain water and soil quality and a healthy environment within the pond. Optimum feeding was followed taking utmost care to avoid overfeeding mainly because of the higher prices for the feed. Majority of the farmers are using branded, pellet feeds for the culture (Kumaran et al. 2001, Reddy et al. 2007). 69.8% of the surveyed farmers operated at more than 90% efficiency implying thereby that the farmers are highly efficient in practices as well as in production (Reddy et al. 2007).

Even though they were seed quality conscious, the habit of bargaining on shrimp seed prices was usual practice which often resulted in crop failures within one month of culture as they admit. Studies have proved that it is the weaker and smaller PL which are most likely to be affected with Vibriosis. The disease management measures adopted along the different places were not satisfactory. To avoid horizontal transmission in case of diseases, the neighboring farmers should be informed about the disease problems, emergency harvest and the time and date of water discharge. During such periods they should avoid water exchange and should not use equipments like nets, tanks, pumps, boat and other utensils which were used in the affected farms. But in some areas this type of practice was not prevalent. Hence it is essential that farmers be motivated to form farmer's co operatives or aquaclubs and management approaches like cluster management be popularized and implemented. The BMPs used by Subasinghe

(2005) recommends removal and safe disposal of sick or dead shrimp and emergency harvesting after proper decision making. The farmers adopting BMPs recorded significant benefits from adopting BMPs and the "aquaclub" formation (Padiyar et al. 2003). Padiyar et al. (2007) reported that the implementation of BMPs and cluster management in the Asia-Pacific region including India, Indonesia, Vietnam, Thailand and Australia showed significant improvements in food safety. Umesh et al. (2007) reported from a mere 5 farmers who adopted the BMPs and cluster management approach in 2002, it swelled to more than 1000 farmers in 30 aquaculture societies in 5 coastal states of India in 2007.

Studies have proved that implementation of BMPs resulted in improvements in both profits and productivity (Subasinghe 2005, Padiyar et al. 2003). In India BMP was reported to be introduced first in Andhra Pradesh where more than 70% of the Indian shrimp production comes from. Subasinghe (2005) carried out the on-farm testing of BMPs in Andhra Pradesh and found improvements in both profits and productivity in demonstration farms with the returns being shifted from a loss in 80% of ponds in 2001 to a profit in 80% of ponds in 2002. Reddy et al. (2007) noted that most of the farmers in A.P are following the best practices in aquaculture though there remains wide gap between the recommended shrimp farming practices and farmer's practices. This study indicated that proper pre requisite practices for HACCP were often followed in most of the shrimp farms studied. The efficiency of the production process can be improved through use of better quality seed, optimum stocking density, improved management of water resources, water quality, proper feeds and feeding techniques, improved usage of chemicals, proper harvest and post harvest techniques etc. Subasinghe (2005) has reported a mean body weight of 18g, Survival rate of 58%, Production of 318kg/ha and a crop duration of 87 days in BMP demonstration ponds in Andhra Pradesh against 12g, 32%, 133kg/ha and 63 days respectively in non demonstration ponds. Temperature was the weakest area of control. This was evident from the lack of control during harvesting and subsequent storage before transportation. In a study conducted in small and medium size food businesses in UK, Walker et al. (2003) found that poor results

(60%) for the implementation of HACCP centered around their temperature control and record keepings. Many had a poor knowledge of cleaning and disinfection procedures and were unaware of the importance of use of chlorine. Poor cleaning and sanitizing practices in foodservice operations were reported (Walker and Jones 2002, Henroid and Sneed 2004, Bas et al. 2006). Kang (2000) is of the opinion that even a perfectly sound HACCP system is not a guarantee of perfect food safety since some portentous hazards, critical points (personal hygiene, handwashing, etc.) cannot always be accurately monitored and corrected. In the measuring and recording category, measuring P^H and salinity was the only practice properly followed by all the farmers, though the results were usually not recorded. Similar observations were made by Bas et al. (2006) in food businesses where the practice of recording was very poor. Observations of difference in actual and measured values in the case of temperature measurements were made in studies conducted by Henroid and Sneed (2004). In the present study also, the P^H and salinity determinations carried out during the field visits showed difference in values (n=31). Almost all the farmers reported that they never calibrate these equipments and many of them did not know the meaning and purpose of calibration. The farmers should use certified and calibrated instruments, tool kits, test strips etc. for accurate measurements. Testing of Dissolved oxygen levels was not usually carried out by all the farmers, yet when the shrimp were seen to suffer from lack of oxygen, preventive measures were taken. Only very few of the farmers reported to be sending water and shrimp samples to a recognized laboratory for bacterial and other testing. This observation is consistent with the food safety ensuring practices observed in studies conducted earlier (Henroid and Sneed 2004).

Even though a number of chemicals are used for various functions, most of them did not know the properties and proper dosage of such chemicals and often the chemical of choice was determined by cost, availability and the influence of the local feed suppliers. There was also found to be heavy prophylactic use of antibacterials in some areas, especially in Kollam district. Graslund et al. (2003) have studied the chemicals and biological products used by the shrimp farmers in Thailand and found that they were using 13 different chemicals and biological products on an average. The most commonly used products were soil and water treatment products, pesticides and disinfectants. Many of these pesticides, disinfectants and antibiotics used by the farmers could have negative effects on the cultured shrimps, cause a risk for food safety, occupational health, and/or have negative effects on adjacent ecosystems. GESAMP (2005) has discussed the chemicals used and made recommendations on the safe and effective use of chemicals in coastal aquaculture. Chloramphenicol and nitrofurans, though banned for use in shrimp hatcheries and aquaculture, enforcement of such bans is weak. Antibiotics were used not only to prevent and treat Vibrio infections, but also in the belief that they could prevent and treat viral infections such as white spot disease. Similar observations have been made by other workers also (Graslund et al. 2003).

Studies by Deboral in 2002 and 2003 also found lack of training programmes as one of the constraints faced by the farmers of Tamil Nadu and emphasised that the farmers wanted to undergo training programmes in disease, water and soil management. S!anchez and Muir (2003) found that 55.8% of the farmers were not satisfied when asked about the technical assistance available in a study conducted in Mexico. Studies by Kumaran et al. (2008) have shown that private extension agents appeared nearer to the shrimp farming community in coastal Andhra Pradesh and Tamil Nadu and suggested that fishery extension service should be accorded as the major function of state fisheries departments. The reasons for using a HACCP system can be due to customer demands, self improvement and legal compliance (Mortimore 2001). The main idea behind HACCP is that it is possible to identify potential hazards and faulty practices at an early stage in food production in order to prevent or minimize risk to health of the consumer or economic loss to the producer. The trend of increasing numbers of disease outbreaks and perceptions regarding the hazards of chemical residues in aquacultured products are an increasing matter of concern among consumers as well as producers. Consequently, importing countries have imposed residue monitoring programs for imports. HACCP is becoming the ``food passport" to the international market place (Gagnon et al 2000). HACCP system is important for maintaining food safety and shrimp being an export commodity, there is need for implementation of international quality and safety norms like PRP and HACCP in shrimp farming. Bryan (1990) attributed lack of usage of HACCP as the most important factor responsible for many foodborne illnesses between 1973 and 1982 in the retail food and restaurant operations in USA. HACCP system is needed for all food businesses for catching up in the modern world (Sun and Ockerman 2005). Consumers in high income countries have become more aware of food safety risks and demand greater guarantees regarding product handling. At the same time, many developed countries are modifying their food safety regulations to emphasize process control and prevention of risks throughout the production process. These trends mean that meeting food safety standards is a challenge for food product exporters (Unnevehr 2000). Panisello and Quantick (2001) pointed out that until barriers impeding HACCP have been solved, HACCP systems will not be implemented throughout the whole food chain and it will not be able to reach its full potential as prerequisite for the international trade of foodstuffs. In the present study, it was observed that shrimp farmers often lose interest and they often have a negative attitude towards food safety problems. Similar observations have been made by different workers from different countries (Taylor 2001, Walker and Jones 2002, Henroid and Sneed 2004, Bas et al. 2007). Subasinghe et al. (2007) reported that aquaculture certification of shrimp, recently introduced can raise the standards for the whole industry and act as a link between different stakeholders in the production and marketing chain. However, it is also pointed out that the trend towards certification risk is disadvantageous to the small scale shrimp farmers particularly in Asia where bulk of the production comes from smaller farms, unless positive actions are taken to involve small scale farmers by developing focused strategies to ensure their participation.

4.5 Conclusion

This study points out that lack of usage of HACCP is responsible for many crop failures occurring after stocking as well as rejections or detentions of exported shrimp on the ground of presence of hazardous chemicals. The availability of good quality, virus free shrimp seeds is essential for the successful grow-out operations. The problems identified during the present study were low influent water quality, non certified seed, feed, fertilizers and drugs, careless effluent discharge, poor post harvest handling and lack of training. The main constraints to HACCP implementation perceived by the farmers were lack of motivation, lack of technical and financial support. Since, most of the farmers presently have limited understanding of the PRP and HACCP strategy, proper food safety training should be provided. It is not possible for any extension agency to reach the nook and corner and train each and every shrimp farmer. Hence it is suggested that the shrimp farming industry may be classified into 3-tier or 4-tier districtwise, areawise, clusterwise etc. for the easy dissemination of information and the representatives can be trained initially. Since the shrimp farmers often lose interest and have a negative attitude towards food safety problems, they should be properly motivated and encouraged to form clusterclubs. There is need for research work on optimum nutrition and health management in the shrimp farming sector. In addition, basic fish health management measures aimed at preventing and reducing risks of disease outbreaks, dosage and use of chemicals and drugs etc. were often not known to the farmers. They need be trained on good health management aspects. In the present study, it was observed that middlemen such as traders, suppliers and salesmen were found to have an important role in exchanging and disseminating information on safe and effective use of chemicals. Hence it is essential that information on safe and effective use of chemicals through training should be extended not only to farm operators but also to these people. Results of this study can be used to develop programs for implementing HACCP procedures in shrimp farming. Because this study was done only in scientific farms, generalizing these findings may be limited. But the results suggest areas of focus for the development of HACCP systems and related PRP in shrimp farming. Overall results indicated that proper shrimp farming practices were often followed in most of the farms studied in Kerala.

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Chapter - 5

THE CHEMICAL AND MICROBIAL HAZARDS IN BRACKISH WATER ENVIRONMENTS AND THEIR INFLUENCE ON CULTURED SHRIMP

5.1 Introduction

Cultured shellfishes are alleged to contain high levels of toxic heavy metals, antibiotics and organochlorine pesticides, which pose serious health hazards to the consumers. Health concerns have been expressed over the years with regard to the overuse and use of unapproved antibiotics in aquaculture operations and the presence of residues in the harvested bshrimp. Pesticides used in agricultural farms as well as industrial run offs ultimately reaches the aquatic environment and pollutes the environment and fishes grown in such environments tend to accumulate these hazards in their body. The microbiology of farmed shrimp has been studied extensively in India and abroad. (Nayyarahamed et al. 1995, Twiddy and Reilly 1995, Surendran et al. 2000, Gopal et al. 2005). It is generally accepted that the environment reflects on the microflora associated with fish (Shewan 1962, Horsley 1971). Wide variations in the microflora under different culture environments have been reported. The shrimp farm water quality parameters have been studied by several workers (Smith et al. 2002, Abraham et al. 2004, Arnold et al. 2006). This study investigates the amount of hazards present in farming environments and their influence on the safety of farmed shrimp. Total bacterial counts, indicator bacteriae like total coliforms and faecal coliforms, faecal streptococci, human pathogenic bacteriae like salmonella, Listeria monocytogenes, Vibrio cholerae and vibrio parahaemolyticus as well as heavy metals, pesticides and antibiotics were monitored in respect of farm environments and farmed shrimp.

5.2 Materials and Methods

The farms selected for the study were surrounded by brackish water canal on one side and culture farms on other sides. The water, sediment and shrimp samples were collected as per recommended procedures. Detailed methodology is given in Chapter 3.2.

5.3 Results and Discussion

5.3.1 Physico-chemical characteristics of brackish water shrimp farms

Smith et al. (2002) reported that feeding strategy used in the commercial culture of shrimp had significant impact on pond water quality and hence growth, health and survival of the shrimp. Abraham et al. (2004) studied the bacteria involved in nitrogen and sulphur cycles and physicochemical characteristics of water and sediment in traditional, modified extensive and semi-intensive shrimp culture systems of West Bengal, India and found that the physicochemical parameters, except salinity and sediment pH, were well within the optimum levels recommended for shrimp culture. It has been reported that culture practices such as feeding with livestock waste or agricultural byproducts have profound influence on the contamination of farm and shrimp. Arnold et al. (2006) observed that the mean water quality parameters were within levels recommended for culturing juvenile penaeids and the highest recorded TAN concentrations were considerably below lethal concentrations reported for juvenile P. monodon.

Table 5.1 Physico-chemical parameters of selected shrimp farms

Parameters	**Shrimp farm water**
Hardness, ppm	1580
pH	8.5
Alkalinity, ppm	90
Dissolved Oxygen, %	34.2
Free and saline ammonia, ppm	0.1
Salinity,ppm	8475
Total suspended solids, ppm	74
Total organic carbon, ppm	4.2
Nitrate, ppm	0.2
Surfactants, ppm	0.9
COD, ppm	21.7
BOD, ppm	9.4

The water quality parameters of selected brackishwater farms of three districts of Kerala are shown in Table 5.1. All the farms registered the water quality parameters within the acceptable limits. The results indicated that there were no remarkable variations between the farms in the three districts and the values given in Table 5.1 are the average of values obtained for three farms. Table 5.2 shows the Indian Standard quality specifications for brackish water shrimp farming. Optimum Water quality parameters for brackish water Shrimp culture (Ravichandran and Pillai 2004) is shown in Table 5.3. Studies have shown that the microbial and physicochemical parameters i.e, temperature, pH, dissolved oxygen (DO) and salinity has a great role in the total productivity of a shrimp farm. DO is one of the most important parameters in water quality assessment and reflects the physical and biological processes prevailing in the pond. In the pond, pH changes diurnally and seasonally due to various reasons and temperature controls the major biological reactions and other parameters of water. Salinity changes the microbial flora of the pond. Influence of season on the physico chemical and microbial characteristics has been extensively studied. Islam et al. (2004) studied the fish and shrimp processing effluents and found that the effluents are very high in biological oxygen demand, chemical oxygen demand, total suspended solids, fat-oil-grease, pathogenic and other microflora, organic matters and nutrients, etc. and therefore, highly likely to produce adverse effects on the receiving coastal and marine environments.

Table 5.2 Quality tolerances for brackish water for commercial shrimp culture

Parameters	**Tolerance limits**
Color and odor	
Floating material	No noticeable color or offensive
Suspended solids	odor
P^H value	No visible floating matter
Free ammonia (as N) mg/l,Max.	No visible suspended solids
Phenolic compounds (as C_6H_5OH), mg/l	6.5 to 8.5
Max.	1.2
Dissolved Oxygen, mg/l, Min.	0.1
Pesticides (chlorinated hydrocarbons) as	3
Cl, mg/l, Max.	0.002
Arsenic (as As), mg/l, Max.	0.2
Mercury (as Hg), mg/l, Max.	0.0003
Oil and greasy substances (sampled in	0.1
30cm surface layer), mg/l, Max.	5
BOD (5 days at 20^0c), mg/l, Max.	1000
Coliform bacteria(MPN index /100ml),	Not less than 90% of test animals
Max	shall survive in 96-hour test
Bio-assay test	

IS: 7967-1976(Reaffirmed 2003)

Table 5.3 Optimum water quality parameters for brackish water shrimp culture

Water quality parameters	Optimal range
Temperature (^{0}C)	28 to 33
Transparency (cm)	25 to 45
P^H value	7.5 to 8.5
Dissolved Oxygen (ppm)	5 to 7
Salinity (ppt)	15 to 25
Total alkalinity (ppm)	200
Dissolved Phosphorus (ppm)	0.1-0.2
Nitrate N (ppm)	<0.03
Nitrite N (ppm)	<0.01
Ammonia N (ppm)	<0.01
cadmium (ppm)	<0.01
Chromium (ppm)	<0.1
Copper (ppm)	<0.025
Lead (ppm)	<0.1
Mercury (ppm)	<0.0001
Zinc (ppm)	<0.1

(Ravichandran and Pillai 2004)

5.3.2 Bacteriological characteristics of brackish water shrimp and farms

The total plate count, counts of coliforms, faecal coliforms and faecal streptococci are shown in Table 5.4. It was observed that the TPC of water and mud of farm B was lower than that of the other farms. Corresponding decrease in the TPC of shrimp muscle was also noted for shrimp from farm B. TPCs were of the order of 10^5 cfu/ml for water, 10^6 to 10^7cfu/g for sediment and 10^6 cfu/g for whole shrimp. The studies conducted by Surendran et al. (2000) have reported TPCs of similar range in shrimp from brackish water farms. Levels of total coliforms, faecal coliforms and faecal streptococci were high in farm A compared to other farms. Since the farms were not connected to human inhabitation in the vicinity and surrounded by brackish water bodies and other farms on all the sides, there is no chance for direct faecal pollution and the source of pollution could be the intake water canal.

Table 5.4 Bacteriological parameters of farm water, farm sediment and shrimp muscle

Sample	T. Plate Count	T.Coliforms (MPN)	F.Coliforms (MPN)	F.Streptococci (MPN)
Water(count/ml)				
Farm water A	$9.3x10^5$	240	75	39
Farm water B	$7.7x10^5$	43	28	21
Farm water C	$8.4x10^5$	93	75	14
Sediment(count/g)				
Farm Sediment A	$1.1x10^7$	9.33	4.27	2.86
Farm Sediment B	$4.2x10^6$	2.05	1.47	0.357
Farm Sediment C	$7.8x10^6$	3.60	2.31	1.12
Muscle (count/g)				
Shrimp muscle A	$7.5x10^6$	1.10	0.357	0.301
Shrimp muscle B	$1.3x10^6$	0.723	0.301	0.000
Shrimp muscle C	$3.6x10^6$	0.619	0.301	0.301

The incidence of human pathogens in the brackish water farm systems and shrimp muscle is given in Table 5.5. Salmonella could be detected from farm A only, while it was absent in the case of other farms and shrimp. Fertilizers such as fresh cowdung could be the source of contamination. Listeria and *V. cholerae* were absent in all the samples. V. parahaemolyticus was present in the water and sediment samples, but it could not be detected in the shrimp samples. As *V. parahaemolyticus* is a normal inhabitant of the brackish water systems, it is natural that it was present. Surendran et al. (2000) have reported the incidence of indicator organisms like total coliforms, faecal coliforms and E.coli in the brackish water environment. Significant reduction in the bacterial load of farmed brackish water shrimp with chlorination and freezing were reported (Putro et al. 1990, Sunarya et al. 1992). It is evident from this study that the farms differed slightly in physical features, but significantly in bacteriological characteristics. The results of the present study showed that shrimp samples from all the selected sources had high bacterial load. It is largely accepted that the microbiological quality of the production environment influences the microbiological quality of the fish and ultimately the processed product. This also suggests the need for adopting proper quality control measures during raising, harvesting, sorting, transportation to the processing unit and storage in ice prior to freezing. The EU/USFDA standards for fresh frozen shrimp has been shown in Table 5.6.

Table 5.5 Pathogenic bacteriae in farm water, farm sediment and shrimp

Sample	**Salmonella**	**Listeria**	**V. cholerae**	**V. parahaemo lyticus**
Brackish water A	A	A	A	P
Brackish water B	A	A	A	P
Brackish water C	A	A	A	P
Farm Sediment A	P	A	A	P
Farm Sediment B	A	A	A	P
Farm Sediment C	A	A	A	P
Shrimp muscle A	A	A	A	P
Shrimp muscle B	A	A	A	P
Shrimp muscle C	A	A	A	P

P = Present, A = absent

Application of HACCP concept in aquaculture industry (Suwanrangsi et al.1997) can assure control over raw materials, the manufacturing process, the production environment and personnel thereby enabling the assurance of food safety during aquaculture and processing. The study also points to the need for monitoring and controlling the water quality in the common intake water canals. A more detailed study encompassing the farms and water canals in each cluster, areawise and districtwise are required. *V. parahaemolyticus* in shrimp environments in India suggests a probable risk for health of people consuming raw seafood. Therefore, it is recommended to pay attention to post-harvest handling and adequate cooking to safeguard public health (Spaargaren 1997). Studies have indicated that the applications of HACCP also helped to reduce the microbial population in the foods (Hatakka 1998). Supporting programs for HACCP by staff training and microbiological analysis were suggested (Kang, 2000). Sung et al. (2001) correlated the presence of a large number of vibrios in the pond water and shrimp hepatopancreas during cultivation with the growth retardation and later mass mortality of tiger shrimp *Penaeus monodon*. In the study by Soriano et al. (2002) in a university restaurant, they found that the introduction of HACCP system improved the microbiological quality and food safety of some university restaurants. Gopal et al. (2005) studied the microbiota of brackish water shrimp, sediment and pond water and found Vibrios constitute a major portion of the microbiota in brackishwater pond ecosystem.

Table 5.6 EU/FDA standards for fresh frozen shrimp

Microbiological Parameters	Permitted levels
TPC at 37^0c	$5x10^5$/g
E.coli	20/g
Coagulase positive Staphylococci	100/g
Salmonella	Absent in 25g
Vibrio cholerae	Absent in 25g

5.3.3 Chemical hazards in brackish water shrimp and farms

The chemical hazards likely to occur in aquacultured shrimp have been discussed under chapter 2 (2.5.4.1). In the present study, the organo chlorine pesticides, heavy metals and the antibiotic, chloramphenicol in the farm environments and shrimp are discussed.

5.3.3.1 Organo Chlorine Pesticide Content in Farm Water and shrimp

The levels of organo chlorine pesticides in several species of fish has been extensively studied the world over. Radhakrishnan (1994) has reported low levels of organo chlorine pesticides in shrimps and oysters from farms in South India. Kannan et al. surveyed organo chlorine pesticide levels in fish from tropical Asia and Australia and found that the content of organo chlorine residues were at low (ppb) levels (Kannan et al. 1994, Kannan et al. 1995). The farm water was analyzed for the 13 organo chlorine pesticides and the results are shown in Table 5.7. The pesticides that were noticed in the farm water include bBHC, Dieldrin, Endrin, pp DDD and pp DDT. Of these, pp DDT was found to be the most dominant pesticide present at 0.39 to 0.44 ppb levels. The use of DDT as a pesticide has been banned in many countries. There was no significant difference in the total organo chlorine pesticide contents among the three farms studied. The pesticide levels noticed in farm waters were below the maximum permissible levels stipulated by BIS.

Table 5.7 Pesticide content in farm water in ug/l

	Brackish water A	Brackish water B	Brackish water C
a BHC	0.00	0.00	0.00
gBHC	0.00	0.00	0.00
bBHC	0.01	0.00	0.04
Heptachlor	0.00	0.00	0.00
Aldrin	0.00	0.00	0.00
Hep.Epo	0.00	0.00	0.00
pp DDE	0.00	0.00	0.00
Dieldrin	0.00	0.08	0.06
op DDD	0.00	0.00	0.00
Endrin	0.00	0.03	0.05
pp DDD	0.01	0.02	0.03
op DDT	0.00	0.00	0.00
pp DDT	0.44	0.41	0.39
TOTAL	0.46	0.54	0.57

The shrimp samples from the selected farms were analyzed for the 13 organo chlorine pesticides and the results are presented in Table 5.8. In the present study, Pp DDT was the dominant pesticide in shrimp samples also. The other organo chlorine pesticides noted were gBHC, bBHC, aldrin, pp DDE, Dieldrin, op DDD, Endrin and pp DDT. Low levels of pesticide contents noticed in the shrimp samples indicates that the farming environment was clean and unpolluted. The pesticide levels noticed in shrimp samples were within the maximum permissible levels stipulated by BIS. The maximum permissible residual levels of pesticides are shown in Table 5.9. The low levels of organo chlorine pesticide levels in the farmed shrimp may be due to lower periods of exposure, i.e for 3-4 months. This period is comparatively lower, compared to their wild counterparts. Studies have pointed out that the level of organo chlorine pesticide in fish is related to the amounts of these compounds present in their diet. Howgate (1988) observed that the organo chlorine pesticide content in the flesh of cultured fish in intensive culture systems depends on the pesticides contained in their feeds. Santerre et al. (2000) reported that the risk to consumers in consuming cultured fish is lower compared to fish from the wild. Sea is the final destination for the agricultural, industrial and domestic effluents carrying these hazards and so it is quite natural that the wild shrimp might be more contaminated.Therefore, this study rules out the possibility that cultured shrimp is less safer for consumption.

Table 5.8 Pesticide content in farmed shrimp in ng/g

Pesticide	**Brackish water shrimp A**	**Brackish water shrimp B**	**Brackish water shrimp C**
a BHC	0.0	0.0	0.0
gBHC	0.1	0.0	0.0
bBHC	0.0	0.1	0.0
Heptachlor	0.0	0.0	0.0
Aldrin	0.2	0.0	0.2
Hepta epoxide	0.0	0.0	0.0

pp DDE	0.1	0.0	0.0
Dieldrin	0.1	0.0	0.0
op DDD	0.0	0.3	0.0
Endrin	0.0	0.0	0.1
pp DDD	0.0	0.0	0.0
op DDT	0.0	0.0	0.0
pp DDT	0.0	0.8	0.3
TOTAL	0.5	1.2	0.6

Smith and Gangoli (2002) reported that despite regulatory bans or strict limits on usage being imposed on organochlorine pesticides in most countries, these compounds continue to be detected in measurable amounts in the eco-system including marine life though in below levels likely to adversely affect human health in fish intended for human consumption. Graslund et al. (2003) reported that shrimp farmers in Thailand were using more than 290 different chemicals and biological products including soil and water treatment products, pesticides and disinfectant, with 13 chemicals on an average.

Table 5.9 Max. permissible residual level for pesticides

Pesticides	**Max. permissible residual level in ppm**
BHC	0.3
Aldrin	0.3
Dieldrin	0.3
Endrin	0.3
DDT	5.0

5.3.3.2 Heavy Metal (Cd,Pb,Ni,Co,Cu,Mn,Zn)Content in Farm Water and shrimp

Table 5.10 Heavy metal content in shrimp farm water (in ppm)

Heavy metal	Shrimp Farm A	Shrimp Farm B	Shrimp Farm C
Cadmium	ND	ND	ND
Lead	ND	ND	ND
Nickel	0.003	0.004	0.005
Cobalt	0.004	0.001	ND
Copper	0.001	0.005	0.002
Manganese	ND	ND	ND
Zinc	0.0064	0.0071	0.0077

The farm water was analyzed for seven heavy metals and the results are shown in Table 5.10. Among the seven heavy metals analyzed Cadmium, lead and manganese were not seen in detectable levels in farm water. Of all the heavy metals analyzed zinc was found to be the most abundant one. Other metals nickel, cobalt and copper were present only in small quantities. Heavy metals like Cadmium, lead and mercury are considered as harmful elements and cumulative poisons.

Table 5.11 Heavy metal (Cd,Pb,Ni,Co,Cu,Mn,Zn) content in farmed shrimp (ppm)

Heavy metal	Shrimp A	Shrimp B	Shrimp C
Cadmium	0.04	ND	ND
Lead	1.1	1.3	1.2
Nickel	0.63	0.34	0.84
Cobalt	0.07	0.25	0.30
Copper	6.50	8.23	11.16
Manganese	0.95	1.35	1.68
Zinc	20.84	21.03	18.16

The shrimp samples were also analyzed for seven heavy metals and the results are shown in Table 5.11. Among the seven heavy metals analyzed cadmium was not seen in detectable levels. Of all the heavy metals analyzed zinc was found to be present in significant amounts followed by copper and other metals nickel, lead, cobalt and manganese were present only in small quantities. Heavy metals like Cadmium, lead and mercury are considered as harmful elements and cumulative poisons. The heavy metals listed in Table 5.11 are well below the maximum permissible levels shown in Table 5.12.

Table 5.12 Max. permissible residual level for heavy metals

Heavy Metals	**Max. permissible residual level in ppm**
Mercury	1.0
Cadmium	3.0
Arsenic	75
Lead	1.5
Tin	250
Nickel	80
Chromium	12

5.3.3.3 Antibiotic Content in Farmed Shrimp

The chloramphenicol present in the shrimp samples were determined using LC/MS/MS/System. In the present study, it was found to be absent in all the three shrimp samples tested.

The chloramphenicol present in the shrimp samples were also determined using CHARM II system. The interpretation table and standard reference table for chloramphenicol are shown in Table 3.1 and 3.2 respectively. The more antibiotic originally present in the sample, the lower the counts will be. In the present study, the counts obtained were above 2000 and hence chloramphenicol content obtained was negative or nil. The maximum permissible levels of antibiotics and other pharmacologically active substances are shown in Table 5.13.

Table 5.13 Antibiotics and other pharmacologically active substances

Antibiotics	**Max. permissible residual level in ppm**
Tetracycline	0.1
Oxytetracycline	0.1
Trimethoprim	0.05
Oxolinic acid	0.3

5.3.2 Sulphite Content in Farmed Shrimp

Dipping shrimps in sodium metabisulphite solution is a normal practice to prevent black spot formation. Usually shrimp is dipped in 0.2 to 0.5% solution for 1 to 2 minutes. The values of residual sulphite detected at different points after harvest are shown in Table 5.14.

Table 5.14 Sulphite content at various stages of processing

After initial treatment at farm site	3.4- 6 ppm as SO_2
After final treatment at processing plant	32- 47 ppm as SO_2
In the product after freezing	42- 80 ppm as SO_2

The sulphite content was analysed at three points; 1) after initial treatment at farm site, 2) after final treatment at the processing plant and 3) in the product after freezing. Whole shrimp was used for the study in all cases. At the farm site, it was observed that the shrimp was kept in ice after the dip treatment in sulphite solution. However, this practice was not observed widely. The residual sulphite detected ranged from 3.4 to 6 ppm. A second treatment at processing plant was also noticed. The concentration used for the final treatment was higher in comparison to the concentration used at the farm site. In the final product after freezing, the residual sulphite detected ranged from 42 to 80 ppm. The maximum residual level recommended for sulphite is 100 ppm as SO_2.

5.4 Conclusion

Despite the mandatory imposition of HACCP in the seafood processing sector, our shrimp exports mainly comprising of cultured shrimp is under the threat of safety problems. It is well established that the presence of hazards in the product reflects the poor quality of the environment and treatments. Though generalizations based on this study is not possible because of the limited number of samples studied, the present study indicated that the farmed shrimp were safe for consumption and were cultured in clean and unpolluted waters. This study also points to the fact that during brackish water aquaculture of shrimp better care need to be taken to avoid contamination from the environment.

xxx

Chapter - 6

ASSESSMENT OF ADHERENCE TO HACCP PRINCIPLES AND PRP IN SHRIMP HATCHERY OPERATIONS

6.1 Introduction

Success of any farming activity is dependent on the availability of quality seed in required quantity. As the demand for shrimp seed increased with the development of commercial shrimp farming, a number of commercial shrimp hatcheries have also been established. Most of these hatcheries have state-of-the-art facilities for producing healthy and disease free post-larvae (AAI, 2002). There are 260 shrimp hatcheries in operation in the country with a total annual production capacity of 10.8billion shrimp seed (PL20). These hatcheries are mostly located in the east coast states, with the maximum number (133) in Andhra Pradesh followed by 72 in Tamil Nadu and 24 in Kerala. Location of the large number of hatcheries on the east coast is also because of the greater availability of brood shrimp in the Bay of Bengal as compared to the Arabian sea (AAI, 2002). As per the Coastal Regulation Zone Notification, 1991, hatcheries can be set up in permitted areas and do not fall under the category of prohibited activities. *Penaeus monodon* is the most predominant cultured species in India. Wild-caught broodstock forms the only source of shrimp seed even today. The dependence on wild broodstocks which determines the price, production and quality of seeds continues to be a significant bottleneck in hatchery technology (Browdy, 1998). The environmental impacts of the wild shrimp seed fishery as well as the possibility of environmental degradation from mass production of shrimp seed in hatcheries has been documented by several authors (Primavera 1998, Islam et al. 2004). Otoshi et al. (2003) have emphasized the need to produce SPF broodstock under biosecure conditions. Several studies have pointed out the need for a quality criteria for shrimp PL and proposed that the stress tests, which are rapid, inexpensive and simple, can be used by shrimp hatcheries as a good reference for overall seed quality as well as a quality control procedure at earlier stages as a predictive quality criterion or at later stages as a final PL quality criterion (Samocha et al. 1998, Lee 2003, Racotta et al. 2004).

The costs of formulated feed and labor associated with feeding are a major component of the cost of hatchery shrimp production. Several workers have studied the impact of dietary conditions on the overall physiological condition as well as stress resistance of the shrimp fry during early postlarval development (Lemos and Rodrguez 1998, Lavens and Sorgeloos 2000). Studies on bacterial infections in *P. monodon* hatcheries have been carried out by a number of workers (Vaseeharan and Ramasamy 2003, Abraham and Palaniappan 2004, Vaseeharan et al. 2005). The role of biofilm in the survival and persistence of the bacterial shrimp pathogen *Vibrio harueyi* and its possible role in perpetuating infection in shrimp hatcheries has been studied (Karunasagar et al. 1998). The studies on bacterial infections in P. monodon hatcheries by many researchers (Vaseeharan and Ramasamy 2003, Abraham and Palaniappan 2004, Vaseeharan et al. 2005) point out the need for standardisation and safety of drugs used in hatcheries for protection of the environment and humans.

Several researchers have pointed out the possibility of application of HACCP approach to the production and harvesting of livestock, poultry and shellfish and the transportation, storage and marketing of foods (Bryan 1992, Motarjemi et al. 1996). Guidelines on Good Hatchery Management Practices (AAI 2002) and specifications for the PL and requirements for the facility (MPEDA 2002) have been formulated. The barriers to HACCP implementation in food businesses have been examined by several workers from different parts of the world (Gilling et al. 2001, Panisello and Quantick 2001, Vela and Fernandez 2003, Henroid and Sneed 2004, Bas et al. 2007). However, studies examining the barriers to implementation of HACCP in shrimp hatcheries are scanty. There have been no studies examining the possibility of implementing PRP and HACCP as well as the extent to which the safety programs are implemented in shrimp hatchery operations in Kerala. Moreover, over the past few years, the quality of hatchery produced seeds has been deteriorating and disease outbreaks have become very common in hatcheries. It is in this context that the present study becomes significant. This study explores the current shrimp hatchery practices and identifies the problems and prospects of implementing HACCP and PRP in shrimp hatcheries. It is envisaged that the present work may give useful information to the hatchery operators in adopting appropriate hatchery management practices in order to increase production, productivity and returns from the hatcheries as well as other stakeholders. This chapter presents a survey in fourteen leading hatcheries in Kerala to identify the barriers which are obstructing the implementation of HACCP and PRP in shrimp hatchery operations.

6.2 Methodology

A sample of 14 shrimp hatcheries *(Penaeus monodon)* from 5 different districts was selected from the state to study the possibility of implementing HACCP and PRP in shrimp hatchery operations. Selection of respondents and method of assessment were as detailed in Chapter 3.2. To evaluate the results, the model proposed by Gilling et al. (2001) was followed, grouping data in three levels to identify most important barriers and is illustrated in Fig.3.2.

6.3 Results and Discussion

6.3.1 Profile of Hatchery Operators

The expansion of shrimp culture in many Asian countries has been facilitated by the development of large numbers of small backyard hatcheries. In Kerala, except a very few hatcheries run by coastal inhabitants, the rests are run by new industrialists by employing skilled technicians mostly from other states like Andhra Pradesh, Orissa etc. The hatcheries are of Galveston style characterized by the use of highly controlled, clear treated water with controlled inputs and a high rate of water exchange. Most hatcheries use a combination of microalgae, *Artemia* nauplii and artificial feeds. The hatchery operators participated in the study had 8 or more years of hatchery management experience and were between the ages of 35 and 50 years. They were either post graduates in life Science or post graduates or degree holders in Fisheries Science. Technicians from Andhra Pradesh dominate this field. Many of the Keralites were trained in hatcheries in Andhra Pradesh.

6.3.2 Assessment of Adherence to HACCP Principles

At knowledge level, the barrier, lack of awareness (K1) did not exist as all the respondents had heard about HACCP. In the present study, the respondents reported to have heard of HACCP principles from training programmes and journals. Vela and Fernandez (2003) in a similar study attributed the HACCP awareness of the respondents partly due to reading from a letter annexed to the HACCP questionnaire. The awareness also has relation to the educational background of the respondents. The respondents in this study were either post graduates or degree holders in Fisheries Science with >5 years experience in hatchery management. Results about lack of understanding (K2) showed that 42.85 % of the respondents had good knowledge of HACCP, 21.43% had some knowledge and 35.72% had very little knowledge of HACCP. However, when those who said to have good knowledge of HACCP were further asked whether they relate it with safety or quality, only 14.29% of them related the system with safety and 85.71% related it with quality. This clearly shows that their understanding of the concept was very poor and that they had not fully comprehended it. This may be because they are facing lack of time and extension support. These data are similar to those obtained by different authors (Gilling et al. 2001, Vela and Fernandez 2003). The HACCP information dissemination systems available in our country usually comprised of one or two days seminars or workshops are usually providing a lot of information in short periods of time which often fails to give an in depth understanding of the concept by the beneficiaries as well as does not motivate the individuals for self reading and improvement. HACCP, being a dry subject adds to the problem. Several studies have identified lack of awareness as the major barrier for HACCP implementation in food businesses (Panisello and Quantick 2001, Henroid and Sneed 2004, Bas et al. 2007). The Codex Alimentarius (1997), NACMCF (1998) guidelines also recognize that the need for training of personnel in the industry is essential for the effective implementation of HACCP. Taylor (2001) is of the opinion that small companies may have limited access to HACCP information and provide less resources for skill development for them. The less developed industries are less likely to invest in HACCP knowledge acquisition (Patricia et al. 2005). At attitude level, with respect to Agreement (A1), only 50.00% of the respondents agreed that the HACCP system is useful and has long term benefits, while the attitude of the rest was neutral. Full comprehension about the concept is needed to develop the proper attitude (Patricia et al. 2005). At attitude level, self-efficacy (A2) 14.29% of the respondents told that it is possible with the existing staff while 85.71% shared that more personnel is needed to cope with the additional paperwork and controls.

Everybody responded at this point. This may be because they were already facing deficiency of staff. To outcome expectancy (A3), all the respondents showed a neutral attitude. With respect to Motivation (A4), 85.71% of the respondents told that it could be adopted through modifications. But, 14.29%, doubting it as a burden involving changes, told that the system could be implemented only if there exists orders from the top management. Vela and

Fernandez (2003) pointed out that theoretically, motivation does not seem to be a barrier in HACCP application because there is a desire of change if it means safer products and most respondents perceive long term benefits, but still a major problem for implementation is the lack of commitment of the board of directors. The successfulness of the HACCP systems depends on the education, training and motivation of both managing and working personnel (Mortimore and Wallace1998, NACMCF1998, Mortajemi and Koaferstein 1999).

Table 6.1 Barriers to HACCP principles adherence by the hatchery operators

Barrier	**Sub categories**	**Percentage distribution (%) (n=14)**
Knowledge	Awareness (K1)	
	• Heard	100.00
	• Not heard	
	Understanding (K2)	
	• Good	42.85
	• Safety	14.29
	• Quality	85.71
	• Not bad	21.43
	• Bad	35.72
Attitude	Agreement (A1)	
	• Useful	50.00
	• Waste of time	0.00
	• Neutral	50.00
	Self-Efficacy (A2)	
	• Possible with the existing staff	14.29
	• More personnel needed	85.71
	• Neutral	0.00
	Outcome Expectancy (A3)	
	• Not required	0.00
	• Impossible	0.00
	• Neutral	100.00
	Motivation (A4)	
	• Can be carried out, though not compulsory	14.29
	• Needs commitment from the top	85.71
	• Neutral	0.00
Behavior	Cueing mechanism (B1)	NA
	Competence (B2)	NA
	Environmental factors (B3)	NA
	Guidelines factors (B4)	NA
	Environmental/Customer factors (B5)	NA

n= number of hatchery operators, NA=Not asked

Since the knowledge and attitude barriers obstructing HACCP application were prevailing, questions on behavior barrier were not asked. According to Taylor (2001), prompting the underdeveloped food industry sectors towards HACCP guideline awareness, implementation and adherence tends to be more difficult because these industries are reported to be ill-equipped with the required industry intrinsic support system to attain it.

6.3.3 Assessment of PRP Awareness and Adherence

The same participants who were selected for the HACCP adherence study were selected for the PRP awareness, attitudes and practices study. The participants were contacted six months after the PRP survey.

6.3.3.1 Broodstock Selection and Maturation

The questions on broodstock selection and maturation to check the awareness are given in Table 6.2 and the results are given in Fig.6.1. The number in Fig.6.1 corresponds to the question in Table 6.2. The questions on broodstock selection and maturation practices are given in Table 6.14 (1 and 2).

Table 6.2. Awareness regarding Broodstock management aspects

No.	Awareness Questions on Broodstock management (Yes/No)
1	Strains which show symptoms of stress, red pigmentation, lesions on exoskeleton, damage to gills etc. should be discarded
2	The brooders should be transported in disinfected seawater supplied by the hatcheries.
3	The recommended stocking density of the spawners is 6-7 per m2in the ratio 1:1
4	The water depth in the maturation tanks should be 60 cms
5	The noise and disturbance should be avoided when the spawners are left for spawning
6	The feed quantity is 12% of the estimated shrimp biomass
7	The water exchange percentage should be 200%
8	The ablated females should be put in antibiotic solution before transfering to the maturation tanks
9	The potential spawners can be identified by the thickening of the ovary and a diamond pattern in the first abdominal segment

The broodstock was not available in sufficient quantity, though available throughout the year. Most often, it was high priced with very little option for selection. As per fig.6.1, all the participants were aware that the spawners should be free from viral diseases in order to avoid vertical transmission of the diseases and the strains which show symptoms of stress, red pigmentation, lesions on exoskeleton, damage to gills etc. should be discarded (100%). Yet, none of them were adopting the practice of screening the broodstock for WSV and MBV before maturation and spawning. 71.42% were aware that the brooders should be transported in disinfected seawater supplied by the hatcheries. But, the practice of transporting the brooders in hatchery water was not followed in any of the cases studied, instead, the brooders collected from the wild were kept in seawater by the vessel crew. The brooders on arrival at the hatchery were acclimatised, subjected to formalin treatment followed by an antibiotic dip treatment before leaving for spawning. But, the concentration and dipping time of chemicals was a matter of doubt and varied slightly from hatchery to hatchery. Gradual acclimatization of the spawners will help in avoiding bacterial contamination especially attack of Vibrio and reduce mortality. The awareness regarding identification of the spawners was high and all the participants were aware that potential spawners can be identified by the thickening of the ovary and a diamond pattern in the first abdominal segment. There was 100% compliance with respect to the practice of acclimatizing, disinfecting and dipping the spawners in antibiotic solution before release into the maturation tank. However, their knowledge on induced breeding and eyestalk ablation was very poor. With respect to the practice of avoiding soft (moulted) females for eyestalk ablation, full compliance was not noticed in any case, minor deviation in 28.57% cases, major deviation in 21.43% cases and non compliance was noticed in 50.00% cases. The practice of induced breeding was not popular in Kerala. Instead, gravid spawners collected from the wild were commonly used. Only about 14.29% could answer correctly that the ablated females should be put in antibiotic solution before transfering to the maturation tanks. 42.85% of the participants were aware that the recommended stocking density of the spawners is 6-7 per m2 in the sex ratio 1:1. All the participants were aware that the noise and disturbance should be avoided when the spawners were left for spawning. It was known to 35.72% that the water depth in the maturation tanks should be 60 cm. About 14.29% were aware that the water exchange percentage maintained for the broodstock maturation section should be 200%. The water quality parameters checked were salinity, temp. and P^H. 28.58% reported that the feed quantity was decided based on the body weight of shrimp and was 12% of the estimated shrimp biomass. The feeds given were squid, beef, liver, clams, shrimps, polychaetes etc. Prophylactic and therapeutic treatments were given. The antibiotics used were prefuran, erythromycin. and oxytetracycline. Siphoning was done in the morning and evening.

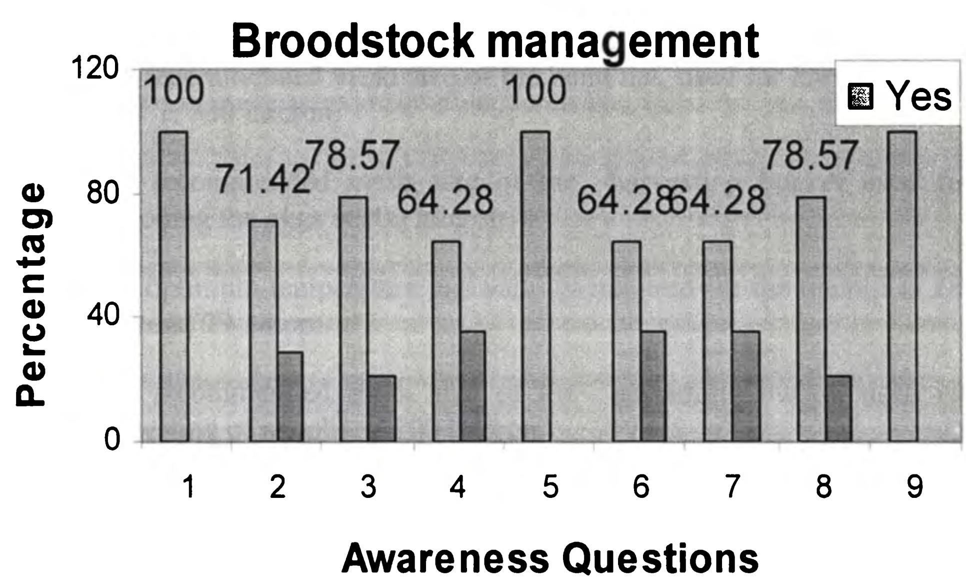

Fig 6.1: Awareness regarding Broodstock management aspects

6.3.3.2 Spawning and Hatching

The questions related to spawning and hatching knowledge and practices are as in table 6.3 (1-10) and table 6.14(3,4 and 7) respectively.

Table. 6.3: Awareness regarding Spawning and hatching management aspects

No.	Awareness Questions on Spawning and Hatching management (Yes/No)
1	Good eggs will appear as a greenish granular accumulation at the bottom of the tank
2	The fertilized eggs can be identified by the symmetrical nature of cell divisions as well as by the presence of appendages and setae
3	The unfertilized eggs appear as opaque or dark brown spheres with irregular cell divisions
4	The recommended mesh size of the hand net used for harvesting the eggs is 350 micron.
5	The recommended mesh size of the harvesting bucket used for siphoning the eggs is 100 micron
6	The optimum temperature and salinity required for the nauplii is 28-320cand 29-34 ppt
7	The recommended mesh size of the harvesting bucket used for harvesting of nauplii is 100 micron.
8	The time lag required for the nauplii to reach the sixth sub stage,N6 is 36 hours
9	The nauplii are attracted towards the light
10	The nauplii pass through three zoeal and three mysis stages before they reach post larval stage

As per fig.6.2, all the participants knew (100%) that good eggs will appear as a greenish granular accumulation at the bottom of the tank. However, only 71.42% could answer correctly the method of identification of fertilized eggs from unfertilized eggs. The compliance to keeping the aeration in the hatching tanks to the minimum level when the spawners were left for spawning was100%. The fertilized eggs can be identified by the symmetrical nature of cell divisions as well as by the presence of appendages and setae whereas the unfertilized eggs appear as opaque or dark brown spheres with irregular cell divisions. After spawning, the eggs were collected immediately and washed well in good quality water followed by washing with formalin and final washing with water. It was known to 85.71% that the mesh size of the hand net used for harvesting the eggs was 350 micron and the mesh size of the harvesting bucket used for siphoning the eggs was 100 micron. The fertility percentage usually obtained was <40% and the number of eggs in a measured volume of egg water was used for calculating the total number of eggs. Most of the hatchery operators were purchasing nauplii from other states like Tamil Nadu. Hence their knowledge on aspects like induced breeding, rearing of eggs and hatchlings etc.was limited. All (100%) were aware that the optimum temp and salinity required for the nauplii is 28-32^{0}c and 29-34ppt respectively. After hatching, the nauplii were thoroughly washed in disinfected water and as a rule, it should be screened for WSV before stocking. Even though, the washing was properly done, screening for WSV before stocking was never practiced. It was known to 92.88% that the time lag required for the nauplii to reach the 6th sub stage, N6 is 36 hours. The nauplii pass through three zoeal and three mysis stages before they reach post larval stage. The awareness score for this aspect was 85.71%. Variations were noticed with regard to the practice of sticking to the optimum stocking density of the nauplii (100,000/ton). Overstocking of the nauplii during periods of high demand especially during the months October to January was common practice. With respect to sticking to the optimum stocking density, full compliance was 7.14%, minor deviation 7.14%, major deviation 14.28% and non compliance 71.43%. 92.88% were aware that the mesh size of the harvesting bucket used for harvesting of nauplii was 100 micron. All of them had noticed that the nauplii were attracted towards the light.

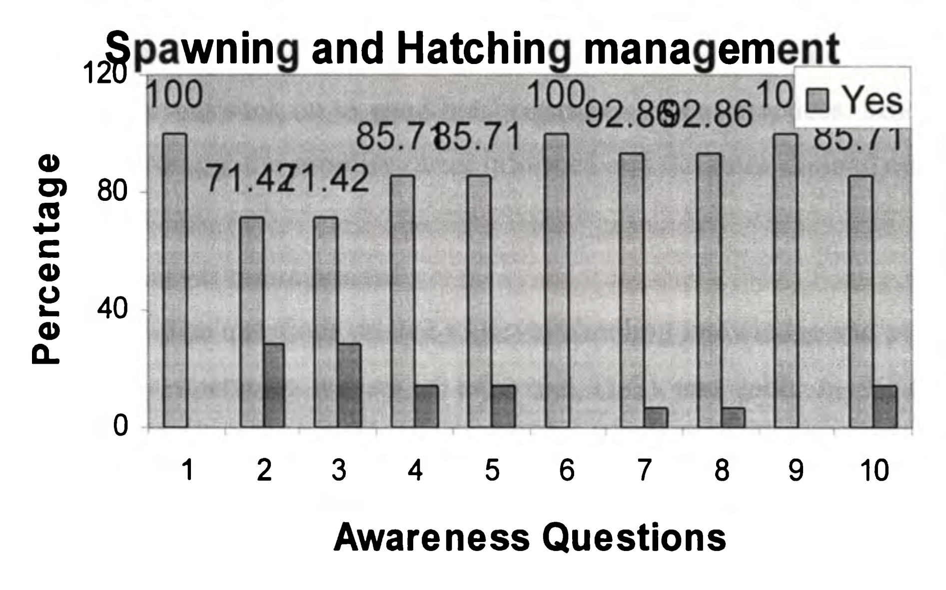

Fig 6.2: Awareness regarding spawning and hatching management aspects

It is general rule that the nauplii with physical deformities such as incompletely formed appendages and setae, twisted setae and those with accumulation of dirt etc. should be discarded. The nauplii that are not active and do not show a fairly regular rhythm of swimming and positive phototaxis also has to be rejected. Also, it is preferable to reject nauplii produced from spawns with hatching rate below 40%. But, the compliance to this aspect was very low with full compliance nil, minor deviation 7.14%, major deviation 21.43% and non compliance 71.43%. In fact, the high price of the brooders had prevented them from complying to this aspect. As >95% of the hatchery owners in Kerala were bringing nauplii from other states like Tamil Nadu, they were unaware of the quality of the parentstock. Also considering the cost involved in airlifting the nauplii, they were forced to further rear whatever nauplii they had purchased irrespective of their health conditions. The nauplii were usually brought in bags of 1litre to 8 litres capacity. The usual density was 50000 nauplii per litre and the cost varied from Rs.10000-18000/=per million. On reaching the hatchery, the nauplii were acclimatized. The acclimatization lasted for 30 minutes to 2 hours depending on the salinity and temperature conditions of the nauplii. A survival rate of 90% was tolerable. If the survival rate was below 80%, usually the lot was rejected. The conversion from each larval stage to the other was critical. If the activity was less or the overall appearance was not good, the technician used to take utmost care and stick on to good hatchery management practices. Still, if the lot was not improving, the suppliers were informed and the stock drained out.

6.3.3.3 Early Larval management

The questions related to larval handling knowledge and practices of the hatchery operators are as in table 6.4 (1-7) and table 6.14(5,6,8,10) respectively.

Table 6.4: Awareness regarding Larval management aspects

No.	Awareness Questions on Larval management (Yes/No)
1	Zoea is the first feeding stage
2	The larval rearing from N6 to PL 3 takes 13 days
3	The adult P,monodon mature, mate and release eggs in the deep
4	oceanic waters
5	The post larvae grow to subadult stage in coastal, brackish waters
	Coastal, brackish waters have a salinity of 5-25ppt whereas oceanic
6	waters have a salinity of 28 to 35 ppt
	The larval phases of P.monodon needs an oceanic environment with
7	a salinity of 28-35ppt
	The nauplii can subsist on yolk

All the respondents were aware that the nauplii can subsist on yolk All of them knew that zoea is the first feeding stage(100%) and the larval rearing from N6 to PL3 takes about 13 days. Their information on the conditions required for the various growth stages of P.monodon was satisfactory. It was known to 78.57% that the adult P.monodon mature, mate and release eggs in the deep oceanic waters and the hatched out larvae dwell in the surface waters of the ocean till they reach the PL stage. 21.43% did not know that the post larvae grow to sub adult stage in coastal, brackish waters. 85.71% were aware that the coastal, brackish waters have a salinity of 5 to 25 ppt whereas the oceanic waters have a salinity of 28 to 35 ppt . 92.86% were aware that the larval phases of P.monodon needs an oceanic environment with a salinity of 28 to 35 ppt.

Usually, the larval rearing from N6 to PL3 was done for about 13 days (full compliance 57.14%, minor deviation 21.43%, major deviation 14.29% and non compliance 7.14%,). However, some of them had noticed that this period can vary depending on the feeding conditions.

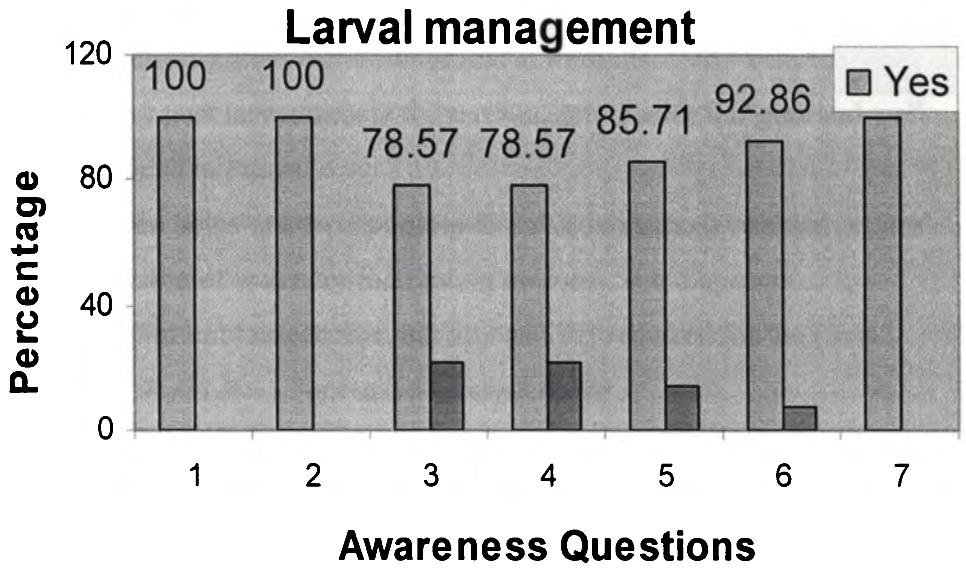

Fig 6.3: Awareness regarding Larval management aspects

They have also noticed that for facilitating faster growth of the zoea, artificial microencapsulated diet also was essential and most of them were in the practice of starting artificial pellet feeding from zoea stage onwards. With respect to the practice of feeding the zoea with phytoplankton, full compliance was noticed in 78.57% cases, minor deviation in 14.28% cases and major deviation in 7.15% cases. This was because some hatchery operators were giving artificial feed from zoea onwards. Variation was also noticed in the case of feeding the mysis with phytoplankton and zooplankton (full compliance 64.28%, minor deviation 21.44% and major deviation 14.28%). The larval rearing room was isolated from other sections of the hatchery to avoid cross contamination in 78.57% cases, whereas minor deviation was noticed in 14.28% and major deviation in 7.15% cases. The PL were usually transferred to the post-larval section at PL-3 stage.

6.3.3.4 Post larval management

The questions related to post larval handling knowledge and practices of the hatchery operators are as in table 6.5 (1-5) and table 6.14(9,11,12,13) respectively.

Table 6.5: Awareness regarding Postlarval management aspects

No.	Awareness Questions on Post larval management (Yes/No)
1	Healthy post larvae appear to be clean, active with full guts and well developed tail muscle
2	Aeration helps to keep optimum dissolved oxygen levels and proper circulation of water for facilitating uniform feed dispersal
3	The optimum temperature, salinity and PH required for the PL is 28+_10c, 31.5+-1.5ppt and 8.2 respectively
4	Larval stages are critical and sensitive phases of shrimp lifecycle
5	Do you know the formula for estimating the number of eggs, nauplii, PL etc. in the tank

Reinforced concrete tanks of 20 ton capacity were usually used for rearing the post larvae. In actual practice, the post larvae were acclimatised before leaving into the PL tanks. The inner surface of the tanks were coated with food grade epoxy paints. The knowledge of the operators in assessing the condition and appearance of the larvae were high. As per fig.6.4, all the participants (100%) were aware that healthy post larvae appear to be clean, active, with full guts and well developed tail muscle. All the participants were aware of the importance of using good quality water in the larval rearing section and were using filtered, chlorinated and EDTA treated water for larval rearing. The water was also treated with antibiotic and antifungal agents as prophylaxis and checked for optimum temperature, PH and salinity regularly and the awareness regarding the optimum limits of these factors were 100%. The optimum temperature, salinity and PH required for the PL is 28 ± 1^{0}c, 31.5 ± 1.5 ppt and 8.2 respectively.

Filtered, dust and oil free air was used for aeration. 85.71% were aware that aeration helps to keep the dissolved oxygen concentration at optimum levels and enables proper circulation of water for facilitating availability of feed to larvae. 85.71% told that the formula for estimating the number of eggs, nauplii, PL etc. in the tank was known to them. All the participants opined that larval stages are the critical and sensitive phases of shrimp lifecycle. The size of the 20 days old PL should be 13 mm. Everybody had realized the fact that the viability of the hatchery depends on the cost of production of post larvae.

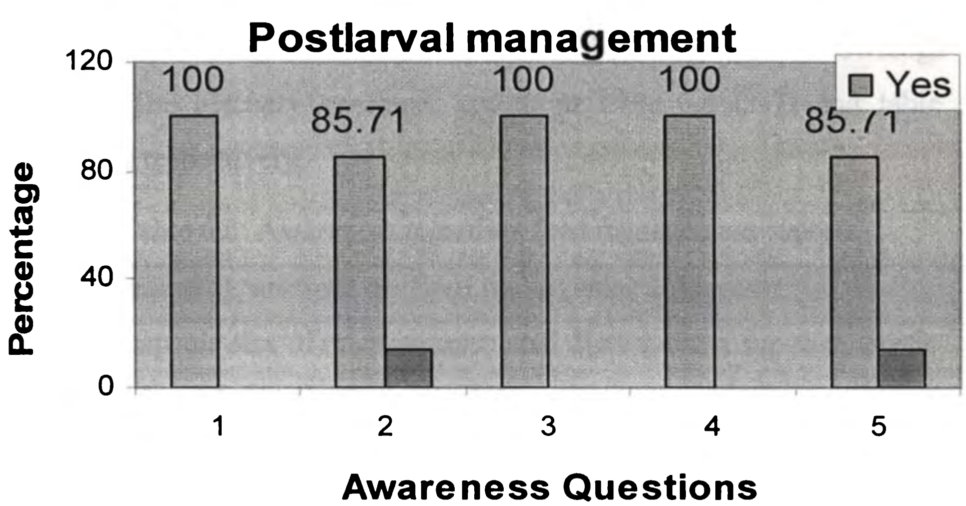

Fig 6.4: Awareness regarding Postlarval management aspects

The usual stoking density of the post larvae was 25-50/lit. But, variations were noticed. During peak seasons, the tanks were seen to be overstocked which often leads to disease outbreaks. The compliance with respect to keeping the optimum stocking density was 57.14% full compliance, 14.28% minor deviation, 14.28% major deviation and 14.29% non compliance. With respect to the practice of transferring the PL to the post larval section at PL-3 stage, full compliance was noticed in 78.57% cases, minor deviation in 14.28% cases and major deviation in 7.15% cases. This was because, in some hatcheries the post larval section was not clearly demarcated and in other cases, especially during peak seasons, the PL were stocked according to the availability of space. In some hatcheries, shade clothes were provided over the tanks to prevent direct sunlight from entering the tanks in the case of outdoor culture (full compliance

71.44%, minor deviation 14.28%, major deviation 7.14% and non compliance 7.14%). In others, PL was cultured outdoor without any roof. Full compliance of 50% was observed with respect to the practice of discarding unhealthy post larvae. Minor deviation, major deviation and non compliance were 7.14%, 14.28% and 28.57% respectively. Non compliance occurs mainly because during periods of high demand they were raising whatever material was available irrespective of the health condition and adjusting the price while selling accordingly.

6.3.3.5 Feed Management

The questions related to feed management knowledge and practices of the hatchery operators are as in table 6.6 (1-7) and table 6.14 (14,21,23,24) respectively.

Table 6.6: Awareness regarding feed management aspects

No.	Awareness Questions on Feed management (Yes/No)
1	The capsule size of microencapsulated diets suitable for zoea, mysis and PL are 5-30, 40-90 and 90-150 microns respectively
2	The feed should be mixed with water before feeding
3	Feeding is one of the important factors determining the growth of
4	larvae
5	The viability of the hatchery depends on the cost of production of
6	postlarvae
7	Zoeal stages need only algae
	Mysis and PLs need artemia nauplii along with algae
	Supplementary feeds along with natural diets are needed for faster and healthy growth

As per fig.6.5, all the participants (100%) were aware that supplementary feeds along with natural diets were needed for faster and healthy growth. The nauplii can subsist on yolk. Naturally, zoeal stages need only algae while mysis and PLs need artemia nauplii along with algae. But in practice, for obtaining faster growth, micro encapsulated diets were also given from zoea stage onwards. 78.57% were aware that zoeal stages need only algae. All were aware that mysis and PLs need artemia nauplii along with algae. Artemia, micro encapsulated diets and egg custard were given to the post larvae (full compliance 71.43%, minor deviation 14.29%, major deviation 7.14% and non compliance 7.14%).

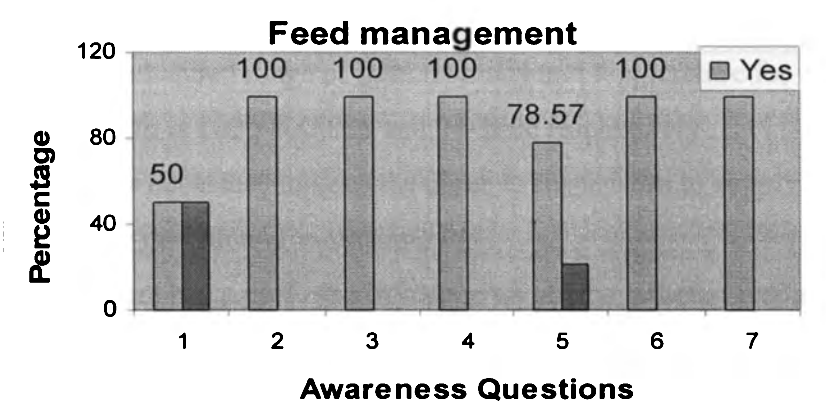

Fig 6.5: Awareness regarding feed management aspects

Algae was fed after water exchange and in the evening. Some have reported that they give egg custard instead of micro encapsulated diets from PL8 stage onwards. This was mainly practiced by the Govt. hatcheries. Compounded, hatchery made feeds were used as substitutes for supplementary feeds during periods of low demand and low selling price in many hatcheries (full compliance 57.14%, minor deviation 7.14%, major deviation 14.28% and non compliance 21.43%). The capsule size of microencapsulated diets suitable for zoea, mysis and PL are 5-30, 40-90 and 90-150 microns respectively. The awareness with respect to this question was 50% only. With respect to the practice of adjusting the feed quality to compensate for the low selling price, full compliance was noticed in 92.86% cases and minor deviation in 7.14% cases. This is a practice which needs immediate attention as the further growth of the PL is suspected to be affected due to underfeeding as well as low nutritious feeding. Fixation of uniform price could solve this problem. Imported feeds were given by 64.29% while 35.71% were using indigenous as well as imported feeds. All the participants (100%) were aware that the feed should be mixed with water before feeding. Everybody knew that feeding was one of the important factors determining the growth of larvae.

6.3.3.6 Algal culture

The questions related to algal culture knowledge and practices of the hatchery operators are shown in table 6.7 (1-8) and table 6.14 (22,25,35,36) respectively.

Table 6.7: Awareness regarding algal culture aspects

No.	Awareness Questions on Algal culture (Yes/No)
1	The recommended range of light intensity and temperature for good algal growth is 1000-8000lux and 24-260c respectively
2	Aeration is necessary to keep the algae in suspension,to supply CO2 needed for growth and to stabilize PH
3	Temperature has a profound influence on photosynthesis, respiration and other metabolic activities of algae
4	The algal culture room should be isolated from other sections of the
5	hatchery
6	Filtered and chlorinated seawater should be used for algal culture
	Vitamins are added to the autoclaved and cooled F/2 medium just before
7	inoculation
8	Prolonged culture results in a decrease in size and nutritive value of algae
	Ten percent inoculum is required at all culture levels to get the desirable cell density

The algal species widely used was Chaetoceros. As per fig.6.6, the recommended range of light intensity (1000-8000lux) and optimum temperature required for good algal growth (24-26^{0}c) was known to 78.57% of the participants while 85.71% were aware that aeration was necessary to keep the algae in suspension, to supply CO_2 needed for growth and to stabilize P^H. It was known to 78.57% that temperature has a profound influence on photosynthesis, respiration and other metabolic activities of algae. The mass culture of algae was started one month before the acquisition of gravid shrimp. The compliance with respect to this practice was full compliance 71.44%, minor deviation 14.28% and major deviation 14.28%. The awareness regarding the importance of having the algal culture room isolated from other sections of the hatchery was 100% and there were separate algal culture rooms in all the cases studied.

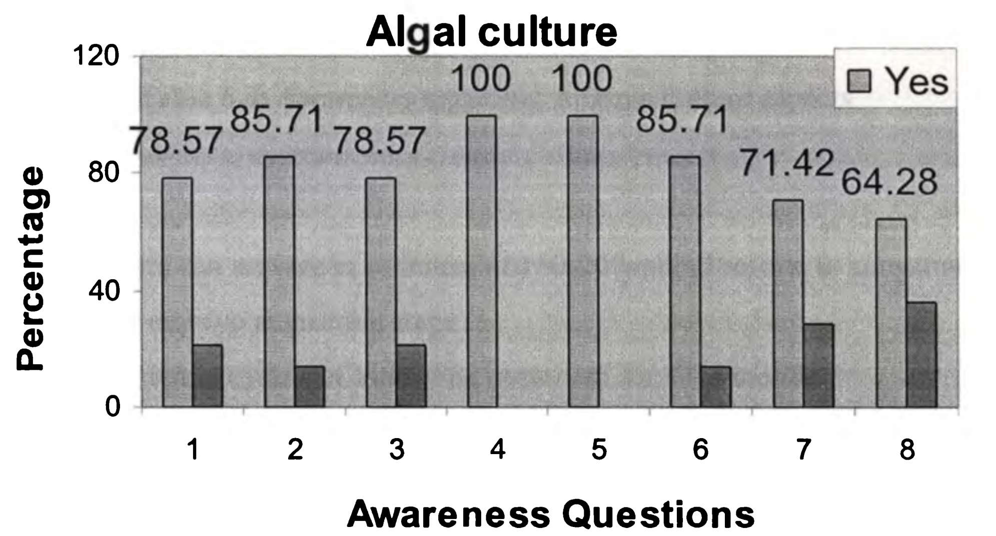

Fig 6.6: Awareness regarding algal culture aspects

The PL was fed with algae after water exchange and in the evening at 3 p.m. With respect to this practice, full compliance was noticed in 42.85% cases, minor deviation in 14.28% cases, major deviation in 14.28% cases and non compliance in 28.59% cases. All were aware that filtered and UV sterilized seawater should be used for algal culture operations. All the items used in the algal section like air hoses, glasswares, airstones, tanks etc. were disinfected before use. Foot dips were provided at the entrance to the algal culture room, but proper chlorination was not done in any of the hatcheries studied. 85.71% were aware that vitamins were added to the autoclaved and cooled F/2 medium just before inoculation. 71.42% were aware that prolonged culture results in a decrease in size and nutritive value of algae. The stock culture was not stored for more than 15 days (full compliance 64.28%, minor deviation 21.43% and major deviation 14.29%) and pure strains of algae were used for mass culture. It was known to 64.28% that ten percent inoculum is required at all culture levels to get the desirable cell density.

6.3.3.7 Artemia culture

The questions related to Artemia culture knowledge and practices of the hatchery operators are given in table 6.8 (1-10) and table 6.14 (26) respectively.

Table 6.8: Awareness regarding Artemia culture aspects

No.	Awareness Questions on Artemia culture (Yes/No)
1	Artemia can survive in salinities of 150-200ppt but resorts to encystment of the embryo at gastrula stage
2	The artemia cysts can usually be preserved for 8-12 months
3	Cysts and cyst shells if introduced alongwith artemia nauplii may bring bacteria into the larval tank
4	The hatching time of artemia cysts is 24-36 hours and continuous aeration is required for efficient hatching of artemia cysts
5	The optimum temperature, salinity PH and light intensity required for efficient hatching of artemia cysts is 28-320c, 25-35ppt, 8-8.5 and 2000lux respectively
6	Whether special FRP tanks with transparent conical bottom for hatching of artemia cysts is needed
7	The artemia cysts should be disinfected in chlorine before stocking in the hatching tanks
8	The hatched out cysts will settle at the bottom and the unhatched shells will float at the surface
9	The harvested artemia nauplii should be thoroughly washed in seawater before feeding to the PL
10	Do you estimate the hatching efficiency and population density

As per fig.6.7, It was known to 64.28% that Artemia resorts to encystment of the embryo at gastrula stage and can survive in salinities of 150-200ppt. The awareness that the artemia cysts can usually be preserved for 8-12 months was 92.86%. 85.71% were aware that the hatching time of artemia cysts is 24-36 hours and continuous aeration was required for efficient hatching of artemia cysts. Their knowledge regarding the optimum temperature, salinity and PH required for efficient hatching of artemia cysts (28-32^{0}c, 25-35ppt, 8-8.5 respectively) was 78.57%. 42.85% were aware that special FRP tanks with transparent conical bottom will be more effective for hatching of artemia cysts. It was known to 71.42% that the artemia cysts should be disinfected in chlorine before stocking in the hatching tanks. The artemia cysts were stocked at a density of 1-2 gm/l (full compliance 64.29%, minor deviation 14.28%, major deviation 4.28% and non compliance 7.15%).

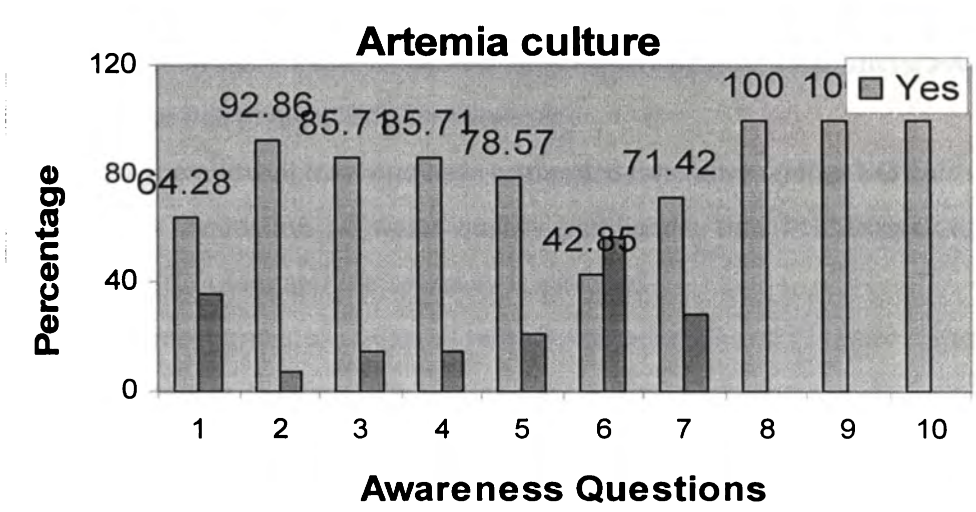

Fig 6.7: Awareness regarding Artemia culture aspects

There was 100% awareness that the hatched out cysts settle at the bottom whereas the unhatched shells float at the surface. Unhatched cysts and cyst shells were discarded. All were aware that the harvested artemia nauplii should be thoroughly washed in seawater before feeding to the PL. 85.71% of the respondents were aware that cysts and cyst shells if introduced alongwith artemia nauplii may bring bacteria into the larval tank. As a rule, only healthy nauplii should be harvested and fed. But, this was not observed as strictly followed. The hatching efficiency and population density were estimated by all but the practice of enriching the naulpii using HUFA and PUFA was not noticed. The overall awareness of the hatchery operators with respect to the culture of Artemia was satisfactory.

6.3.3.8 Seawater Quality management

The questions related to water quality knowledge and practices of the hatchery operators are shown in table 6.9 (1-9) and table 6.14 (15,16,17,18,19,20,37,45) respectively.

Table 6.9 Awareness regarding Seawater quality management aspects

No.	Awareness Questions on Seawater Quality management (Yes/No)
1	EDTA should be applied to a concentration of 10ppm
2	Do you know the recommended standards for the water quality
3	parameters
	The seawater should be filtered using rapid and slow sand filters(50u)
4	before it is pumped into the reservoir
5	Do you allow at least one hour settlement time after adding EDTA
	Daily evaluation of water quality parameters like PH, temperature,
6	salinity,colour and transparency is essential
	The recommended ranges of salinity, temperature and PH for a shrimp
7	hatchery is 28-35ppt, 28-320c and 8.2-8.5 respectively
8	The water is chlorinated to a level of 5-10ppm
	Chlorination kills all pathogenic microbes as well as chemically
9	removes iron by forming a red precipitate with it
	The effluents should be treated before discharging into the water supply

Shrimp hatcheries draw water from the sea. The water inlet valves were placed about 25-50 meters away from the seashore and the valves were kept covered. In some areas, the seawater intake posed problems owing to the turbid condition of the water in those areas. The water supply system normally includes settling tanks to remove larger particles and a battery of filters for water treatment and disinfection. The filtering system includes sand and carbon filters. There were separate pumps, tanks etc. for freshwater intake and storage. The purpose of filtering water is to exclude protozoans and other naturally occurring undesirable organisms that can compete with shrimp larvae for space and food and which also bring in diseases as well as for obtaining clear, colorless and odorless water.

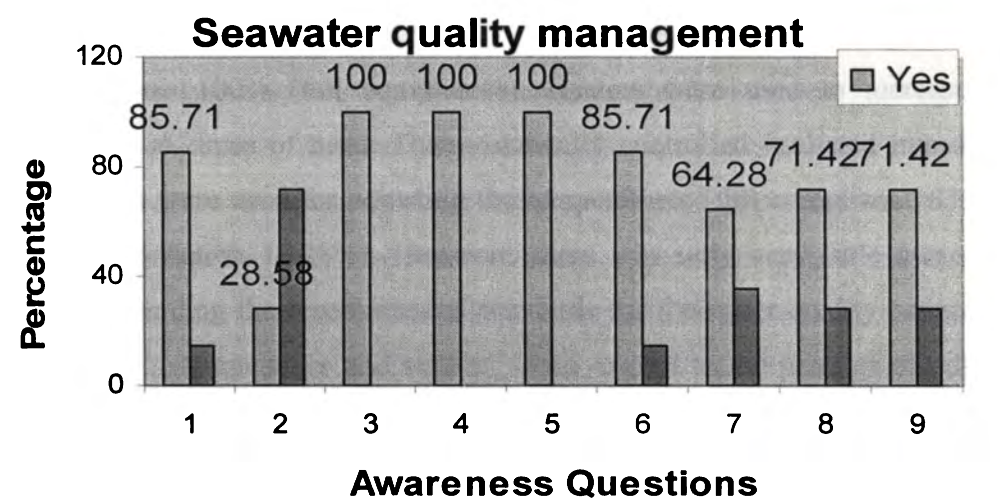

Fig 6.8: Awareness regarding Seawater quality management aspects

The awareness regarding chlorination and the level of residual chlorine was poor. As per fig.6.8, 64.28% of the respondents were aware that the water should be chlorinated to a level of 5-10ppm. The residual chlorination was not checked with the help of any chlorine test kits, instead they were correctly following the usage instructions on the chemicals used. Non compliance 85.72% and major deviation 14.28% was noticed in the case of checking the residual chlorination with the help of chlorine test kits. Bleaching powder was commonly used. It was known to 71.42% that proper chlorination kills all pathogenic microbes as well as chemically removes iron by forming a red precipitate with it. 85.71% were aware that EDTA should be applied to a concentration of 10ppm. However, their awareness regarding the use of EDTA as a chelating agent helping to reduce the concentration of heavy metals as well as bacterial contamination of shrimp eggs, etc. was limited. 85.71% were aware that the recommended ranges of salinity, temperature and P^H for a shrimp hatchery is 28-35ppt, 28-32^{0}c and 8.2-8.5 respectively. All were aware that daily evaluation of water quality parameters like P^H, temperature, salinity, color and transparency was essential and this aspect was fully complied with in all the cases. There was also 100% awareness with respect to the importance of filtering the seawater using rapid and slow sand filters(50u) before it was pumped into the reservoir tanks and allowing a settlement time of at least one hour after adding EDTA etc. The compliance with respect to the practices such as using filtered and treated water, checking the water for optimum temperature, P^H and salinity regularly, removing the waste materials daily, etc. was 100% (full compliance). Heaters were used to increase the temperatures at times of need. Thermostatically controlled insulated immersion water heaters were used for adjusting the temperatures (full compliance 85.72% and minor deviation 14.28%). However, there was only very little awareness (28.58%) regarding the recommended standards for the water quality parameters other than P^H , temperature and salinity. With respect to the practice of sending the water samples to a recognized laboratory for occasional testing, full compliance was 14.28%, minor deviation 21.44%, major deviation 28.57% and non compliance 35.71%. Filtered, dust and oil free air was used for aeration (full compliance 78.57%, minor deviation 14.29% and major deviation 7.14%). Filtered, chlorinated and EDTA treated water was used for larval rearing (full compliance 85.71% and minor deviation 14.29%). Most of them knew that the effluents should be treated before discharging into the water supply. Even though, the awareness to this aspect was 71.42%, compliance was nearly nil.

6.3.3.9 Chemicals management

The knowledge questions related to chemicals management aspects and actual practices of the hatchery operators are shown in table 6.10 (1-17) and table 6.14 (38,39,44) respectively.

Table 6.10: Awareness regarding Chemicals management aspects

No.	Awareness Questions on Chemicals management (Yes/No)
1	When an animal is treated with any chemical, the chemical will generally be absorbed by the animal concerned
2	Is there any recommended standards for the application and use of
3	chemicals
4	EDTA can reduce the bioavailability of heavy metals by complexation

	Chlorine decays with time by the action of sunlight and by use for
5	oxidation of organic matter
6	Formalin is a potential carcinogen and should be handled carefully
	Malachite green is widely used as an antifungal and antiprotozoan
7	agent in shrimp hatcheries
	Malachite green is a respiratory enzyme poison and lengthy withdrawal
8	period is needed following its application
9	Treflan is the most commonly used prophylactic fungicide in shrimp
	hatcheries
10	Use and ingestion of chloramphenicol in humans is associated with
	aplastic anaemia
11	The major environmental hazard of chloramphenicol is its potential to
12	increase drug resistance
13	Erythromycin is active against Gram positive bacteria.
14	Antibacterial agents like nitrofurans are potential carcinogens
	Chloramphenicol is banned for use in shrimp hatcheries
15	Is there proper surveillance programmes to monitor compliance with
16	the regulations
	Do you think such regulations are to be strengthened for better
17	consumer protection
	The importing countries are imposing restrictions on compounds used
	by the shrimp farmers in the exporting countries
	Are the hatchery workers properly trained to handle chemicals

Many chemicals are used in shrimp hatcheries as prophylaxis and against larval diseases without much beneficial effect. Calcium hypochlorite, lime, zeolites, quaternary ammonium compounds like benzalkonium chloride (BKC), iodophores, Copper sulphate, formalin, malachite green, treflan, erythromycin etc. are the common chemicals used by the shrimp hatcheries. Even though the chemical of choice was determined by cost and availability, most of them knew the properties and proper dosage of such chemicals, compared to the shrimp farmers. As per fig.6.9, 71.42 % were aware that when an animal is treated with any chemical, the chemical will be absorbed by the animal concerned. However, only 21.43% of them knew that there are recommended standards stipulated by the regulatory authorities for the application and use of chemicals. Treatment concentrations of chemicals were often decided as per instructions on the product (full compliance 78.57% and minor deviation 21.43%). The score for the information that EDTA can reduce the bioavailability of heavy metals by complexation was 64.28%. It was known to 57.15% of them that chlorine decays with time by the action of sunlight and by use for oxidation of organic matter. The residual chlorination was not observed to be checked with the help of any chlorine test kits. Chloritest papers were not available in any of the hatcheries studied and some of them were not even heard of such test methods. 35.72% were aware that formalin is a potential carcinogen and should be handled carefully while 35.72% were aware of the importance of malachite green for use as an antifungal and antiprotozoan agent in shrimp hatcheries. The awareness that malachite green is a respiratory enzyme poison and lengthy withdrawal period is needed following its application was only 21.43%. 71.42% knew that treflan is the most commonly used prophylactic fungicide in shrimp hatcheries.

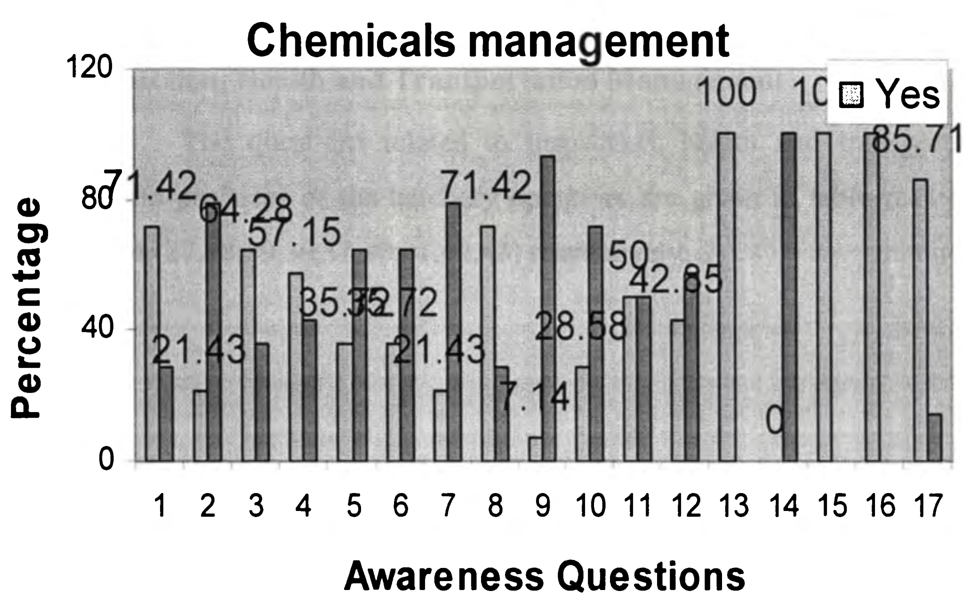

Fig 6.9: Awareness regarding Chemicals management aspects

The information that use and ingestion of chloramphenicol is associated with aplastic anaemia in humans was very limited (7.14%). But 28.58% answered that the major environmental hazard of chloramphenicol is its potential to increase drug resistance. 50% of the participants did not know that erythromycin is active against Gram positive bacteria. It was known to 42.85% that antibacterial agents like nitrofurans are potential carcinogens. Records regarding use of chemicals, daily checks and observations etc. were poorly or not at all maintained. With respect to the practice of storing the chemicals properly, full compliance was observed in 85.72% cases and minor deviation in 14.28% cases. Everybody was aware that chloramphenicol is banned for use in shrimp hatcheries. But the enforcement of such bans was non existent or weakly existent. All were aware (100%) that the importing countries are imposing restrictions on compounds used by the shrimp farmers in the exporting countries . 14.29% told that they are not properly trained to handle chemicals. With respect to the practice of proper record keeping regarding use of chemicals, daily checks and observations etc, minor deviation of 14.28%, major deviation of 57.15% and non compliance of 28.58% was noticed. Everybody urged the need for strengthening the surveillance programmes to monitor compliance with the regulations for better consumer protection.

6.3.3.10 Inspection, Health and Transportation Management

The questions related to inspection, health and transportation knowledge and practices of the hatchery operators are given in table 6.11 (1-7) and table 6.14 (27,28,29,30,31,40,41,42,43) respectively.

Table 6.11: Awareness regarding Health management aspects

No.	Awareness Questions on Inspection, Health and Transportation management (Yes/No)
1	Crop failures are common during peak seasons
2	In case a disease occurs, try to fight against the disease with drugs
3	Viral diseases can't be treated by antibiotics
4	Good hatchery management practices can reduce the risks of diseases
5	Prohibited drugs should not be used for prophylactic treatment
6	The most adversely affecting primary stress factors are undernourishment and overcrowding.
7	The packing density of the PLs in the bag is decided based upon transportation time and size of the PLs

As per fig.6.10, 85.71% admitted that they were facing crop failures during peak seasons.

Most of them preferred to discontinue the operation till the pathogen was eradicated by disinfection and drying in case a disease occurs, however, 14.29% answered that, they will try to fight against the disease with drugs. 78.57% were aware that Viral diseases can't be treated by antibiotics and 71.42% answered that good hatchery management practices can reduce the risks of diseases to a certain extent. All of them were aware that prohibited drugs should not be used for prophylactic treatment (100%). The walk through inspection was carried out many times, at least three times a day. Water condition in the tank, aeration, algal density, artemia density, larval behaviour, general appearance, health, feeding etc. were observed daily.

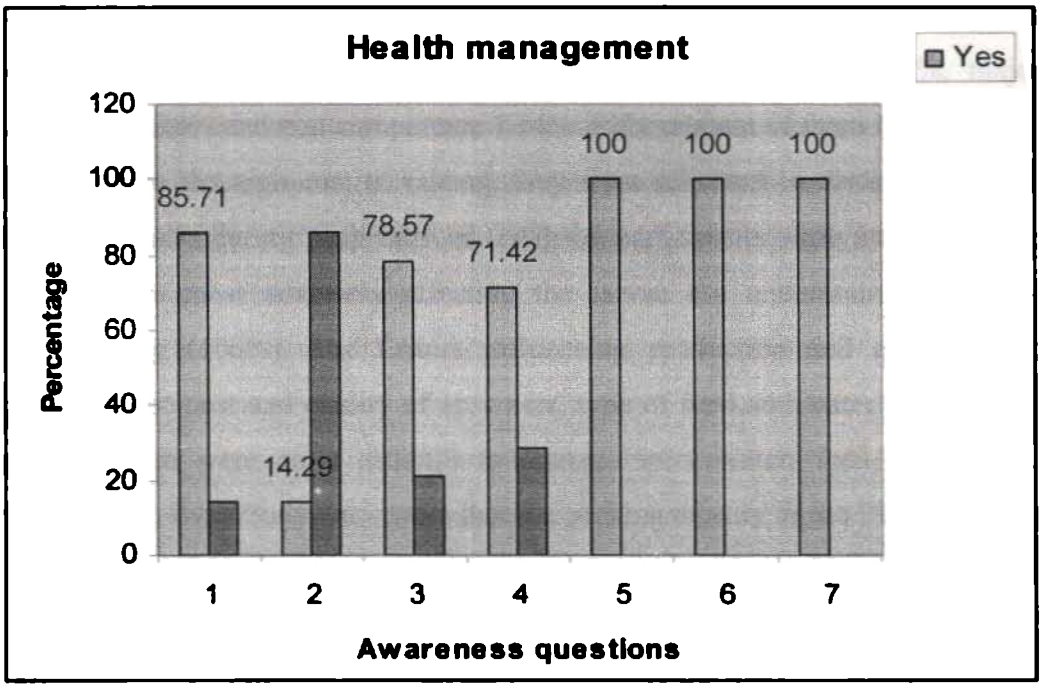

Fig 6.10: Awareness regarding Health management aspects

Microscopic examination on swimming activity, feeding, morphological and developmental stages, Symptoms of stress, presence of parasites and diseases etc. was done as and when required. There was 100% compliance on practices such as carrying out the walk through inspection and observing the condition of the seed daily. However, deviation was noticed with regard to microscopic examination of the seed (minor deviation 28.57% and major deviation 71.43%). The Aquaculture Authority of India guidelines insists that the PL20s should be screened for WSV and subjected to salinity drop test and exposure to 100ppm formalin before sales. In addition, the PL should be checked for activity, pigmentation, survival rate, body length, muscle to gut ratio, microbial infection etc. and infected PLs should not be sold in any case. The shrimp farmers should be given sufficient quantity of PL to conduct the PCR test and, the PL should be sold or purchased, only if found disease free. But in actual practice, the only test conducted before selling the PL was PCR test. Here also, full compliance was noticed in 78.57% cases with minor deviation 14.28% and major deviation 7.14%. Some hatcheries were having own PCR labs. The shrimp farmers taking samples from the hatcheries and testing in recognized laboratories was also common. With respect to the practice of separating the weak seeds before selling, full compliance was 50.00%, minor deviation 28.58%, major deviation 14.28% and non compliance 7.14%. Fifty percent of them had admitted that owing to the high cost of raising, they were reluctant to discard the weak seeds especially during peak seasons. All the participants were aware that the stress factors most adversely affecting the larvae are undernourishment and overcrowding (100%). The factors influencing production and quality were assessed to be cost and quality of spawners, type of feed and water quality. The aspects which were more difficult to manage were water, feed and disease management. Everybody was aware that the packing density of the PLs in the bag is decided based upon transportation time and size of the PLs (100%). The packaging techniques and materials used for packing the PL was satisfactory. There was 100% compliance with regard to reducing the temperature in the tub to 50^{o}c before packing for transportation. The water to oxygen ratio in the transportation packets varied from 1:2 to 1:3. Full compliance of 85.71% and minor deviation of 14.29% was noticed for maintaining the water to air ratio in the transportation packets 1:3. 100% compliance was noticed with regard to avoiding feeding while in transportation as well as packing the PL bags in cardboard cartons lined inside with thermocole sheet with a bag of ice inside during transportation.

6.3.3.11 Infrastructural facilities

The questions related to infrastructure facilities are as in table 6.12 (1-4).

Table 6.12: Awareness regarding Infrastructural aspects

No.	Awareness Questions on Infrastructural facilities (Yes/No)
1	Whether the seawater extracting and filtering system satisfactory
2	There are sufficient numbers of motors, pumps pipelines,aerators,tanks and other utensils
3	The laboratory is equipped with necessary equipments, chemicals, drugs and Seawater testing kits etc.for conducting microbiological and other studies
4	There is a PCR lab attached

As per fig.6.11, only 71.42% were satisfied with their seawater extracting and filtering system. 21.43% told that they were not having sufficient numbers of motors, pumps pipelines, aerators, tanks and other utensils. 57.15% were having their laboratory equipped with necessary equipments, chemicals, drugs and seawater testing kits etc.for conducting microbiological and other studies. 21.43% had a PCR lab attached.

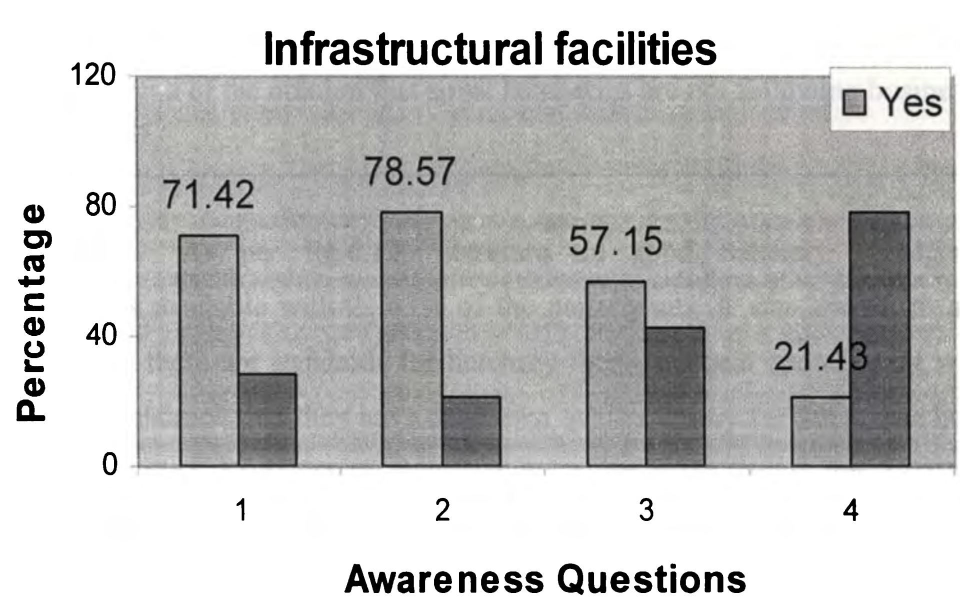

Fig 6.11: Awareness regarding Infrastructural aspects

6.3.3.12 General

The questions related to general awareness and practices are shown in table 6.13 (1-9) and table 6.14 (32,33,34,46) respectively.

Table 6.13 Awareness regarding General aspects

No.	Awareness Questions on General Aspects (Yes/No)
1	Literature on good hatchery management practices is available
2	There are standards for hatchery feeds, influent and effluent waters
3	Do you have a quality policy for the production of good quality seed

4	GMP/PRPs are essential for ensuring the quality of the production and produce
5	Whether PRP/GMP implemented
6	Whether there is any HACCP like schemes in place
7	Do you have any written operating instructions for the process
	Do you give any training to your workforce
9	Are you of the opinion that some hatcheries are not following business ethics

As per fig.6.12, literature on good hatchery management practices was available with 21.43% of the participants. It was known to about 14.29 % that there are standards for hatchery feeds, influent and effluent waters etc. 14.29% claimed that they have their own quality policy for the production of good quality seed. Even though many of them (64.28%) agreed that GMPs are essential for ensuring the quality of the production and produce, nobody had heard the term, PRP. In the earlier HACCP principles adherence study, it was understood that all the respondents had at least heard about the concept. However, the term PRP was not at all familiar to them and this study suggests that the PRP concept needs to be popularized. Though there was agreement regarding GMP as a useful system for ensuring the quality of the production and produce, none had started a move towards implementation of PRP in their hatcheries. However, 57.15% reported that they were having HACCP like schemes in place. Some of them had written operating instructions for the process. 28.58% had documented the process for the purpose of training the staff. All were giving training to their workforce as and when a new person joins. 50% were of the opinion that some hatcheries are not following business ethics. Majority of them claimed that they need research and training support along with credit, infrastructural and marketing support. They urged the need for fixation of uniform price and regulatory controls in the hatchery sector. The cost components were monitored regularly by 64.28%

(full compliance), 7.14% (minor deviation), 14.28% (major deviation) and 14.28% (non compliance). The buyer and the price was often prefixed (full compliance 57.15%, minor deviation 35.72% and non compliance 7.14%). Effluents were often discharged without proper treatment. Full compliance, minor deviation, major deviation and non compliance observed with respect to this practice was 28.57%, 14.28%, 35.72% and 21.43% respectively. Proper record keeping procedures were not there. With respect to the practice of proper record keeping, full compliance of 14.28%, minor deviation of 14.28% and major deviation of 71.44% was noticed. But in some hatcheries which have regular customers, records giving details of the purchasers as well as their history of subsequent culture operations such as, whether success or failure and if failure at which stage etc. were observed to be maintained. In such cases, the hatchery technicians even visit the farms and give necessary technical advice as and when needed.

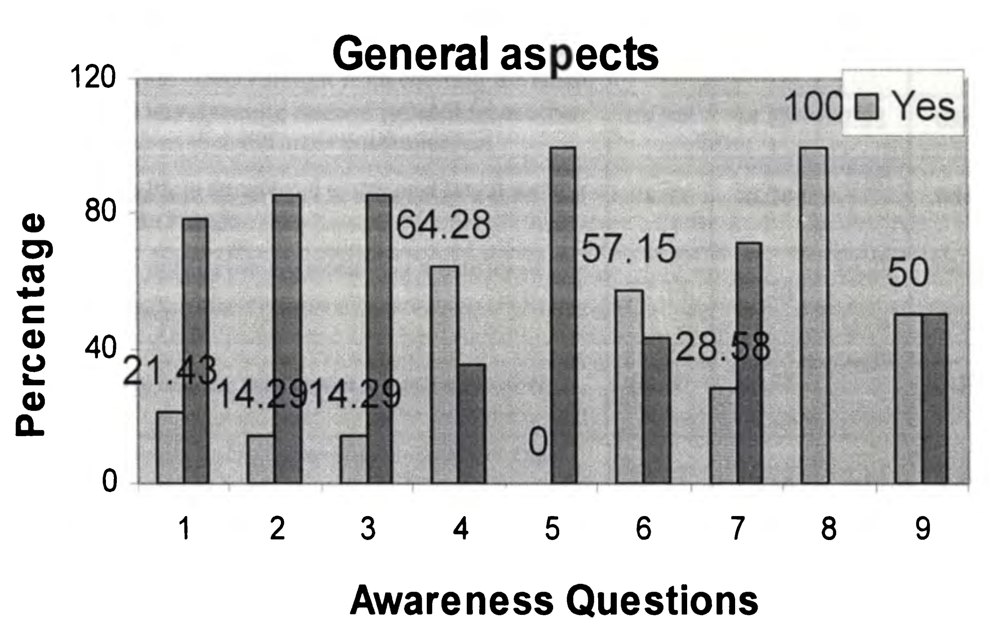

Fig 6.12 Awareness regarding General aspects

Table 6.14 Selected items of HACCP prerequisite programs practices

Sl.No	Observed practices	Full C %	Min D %	Maj D %	Non C %
1	Spawners are acclimatized, disinfected and dipped in antibiotic solution before release into the maturation tank	100.00	0.00	0.00	0.00
2	Soft (moulted) females are not taken for eyestalk ablation	50.00	28.57	21.43	0.00
3	The aeration in the hatching tanks are kept to a minimum level	100.00	0.00	0.00	0.00
4	Inactive as well as those produced from spawns with hatching rate below 40% are rejected	0.00	7.14	21.43	71.43
5	The zoea is given phytoplankton	78.57	14.28	7.15	0.00
6	Mysis is given phytoplankton and zooplankton	64.28	21.44	14.28	0.00
7	The nauplii is stocked at a density of 100,000/ton	7.14	7.14	14.28	71.43
8	The larval rearing from N6 to PL3 is done for about 13 days	57.14	21.43	14.29	7.14
9	Shade clothes are provided over the tanks to prevent direct sunlight from entering the tanks	71.44	14.28	7.14	7.14
10	The larval rearing room is isolated from other sections to avoid cross contamination	78.57	14.28	7.15	0.00
11	The PL is transferred to the post larval section at PL-3 stage	78.57	14.28	7.15	0.00
12	The post larvae are stocked at a density of 25-50/litre	57.14	14.28	14.29	14.28
13	Only healthy post larvae are reared further	50.00	28.57	14.29	7.14
14	Artemia, micro encapsulated diets and egg custard are given to the post larvae	71.43	14.29	7.14	7.14
15	The water is checked for optimum temperature, PH and salinity regularly	100.00	0.00	0.00	0.00
16	Filtered, chlorinated and EDTA treated water is used for larval rearing	85.71	14.29	0.00	0.00
17	Water treated with antibiotic and antifungal as prophylaxis is used	100.00	0.00	0.00	0.00
18	The water sample is sent to a recognized laboratory for testing occasionally	14.28	21.44	28.57	35.71
19	Filtered, dust and oil free air is used for	78.57	14.29	7.14	0.00

	aeration				
20	The waste materials are siphoned out daily	100.00	0.00	0.00	0.00
21	Imported feeds are given	64.29	35.71	0.00	0.00
22	Algae is fed after water exchange and in the evening at 3p.m	42.85	14.28	14.28	28.58
23	Compounded, hatchery made feeds are used as substitutes for supplementary feeds during periods of low demand and low selling price	57.14	7.14	14.28	21.43
24	The feed quality is adjusted to compensate for the low selling price	92.86	7.14	0.00	0.00
25	The algal species used is Chaetoceros	100.00	0.00	0.00	0.00
26	The artemia cysts are stocked at a density of 1-2 gm/l	64.29	14.28	14.28	7.15
27	The temperature in the tub is reduced to 50c before packing for transportation	100.00	0.00	0.00	0.00
28	The water to air ratio in the transportation packets is 1:3	85.71	14.29	0.00	0.00
29	Feeding is avoided while in transportation	100.00	0.00	0.00	0.00
30	Weak seeds are separated before selling	50.00	28.58	14.28	7.14
31	PCR test is carried out before selling	78.57	14.28	7.14	0.00
32	Proper record keeping procedures are there	14.28	14.28	71.44	0.00
33	The cost components are monitored regularly	64.28	7.14	14.28	14.28
34	The buyer and the price is prefixed	57.15	35.72	0.00	7.14
35	The stock culture is not stored for more than 15 days	64.28	21.43	14.28	0.00
36	The mass culture of algae is started one month before the acquisition of gravid shrimp	71.44	14.28	14.28	0.00
37	The residual chlorination is checked with the help of chlorine test kits	0.00	0.00	14.28	85.72
38	The chemicals are stored properly	85.72	14.28	0.00	0.00
39	Treatment concentrations of chemicals are as per instructions on the product	78.57	21.43	0.00	0.00
40	The walk through inspection is carried out at least three times a day	100.00	0.00	0.00	0.00
41	Tank water condition, aeration, algal density, artemia density, animal behaviour, health,feeding etc. are observed daily	100.00	0.00	0.00	0.00

42	Microscopic examination is done on swimming activity, feeding, morphological and developmental stages, Symptoms of stress, presence of parasites and diseases etc. daily	0.00	28.57	71.43	0.00
43	The PL bags are placed in cardboard cartons lined inside with thermocole sheet during transportation	100.00	0.00	0.00	0.00
44	Records are kept regarding use of chemicals, daily checks and observations etc	0.00	14.28	57.15	28.58
45	Thermostatically controlled insulated immersion water heaters are used for adjusting the temperatures	85.72	14.28	0.00	0.00

Full C - Full Compliance, Min D- Minor Deviation, Maj D- Major Deviation, Non C - Non Compliance

6.3.3.13 Areas of low knowledge

Table 6.15 Areas of low knowledge

	Awareness Questions	**Yes (%)**	**No .(%)**
1.	The feed quantity is 12% of the estimated shrimp biomass	28.58 14.29	71.42 85.71
2.	The water exchange percentage should be 200%	14.29	85.71
3.	The ablated females should be put in antibiotic solution before transfering to the maturation tanks	28.58	71.42
4.	Do you know the recommended standards for the water quality parameters ?	14.29	85.71
5.	In case a disease occurs, try to fight against the disease with drugs	21.43	78.57
6.	Is there any recommended standards for the application and use of chemicals	21.43	78.57
7.	Malachite green is a respiratory enzyme poison and lengthy withdrawal period is needed following its application	7.14 28.58	92.88 71.42

8.	Use and ingestion of chloramphenicol in humans is		
	associated with aplastic anaemia	21.43	78.57
9.	The major environmental hazard of chloramphenicol is	21.43	78.57
	its potential to increase drug resistance	14.29	85.71
10.	There is a PCR lab attached		
11.	Literature on good hatchery management practices is	14.29	85.71
	available		
12.	There are standards for hatchery feeds, influent and	28.58	71.42
	effluent waters		
13.	Do you have a quality policy for the production of good		
	quality seed		
14.	Do you have any written operating instructions for the		
	process		

It is evident from table 6.15 that the hatchery operators do not have sufficient knowledge or information in certain areas. The awareness questions which scored below 30% were those relating to the recommended feed quantity for the broodstock, recommended standards for the feed and influent and effluent water quality parameters, application, use and potential hazards of chemicals etc. The information on broodstock management, water exchange rate, disease management also was low. The present study indicates that there is need for supplying the hatchery operators with guidelines on good hatchery management practices as well as motivating them to subscribe current publications or journals in the related field for updating their knowledge and hence the practices. This study also suggests the need for improving the infrastructural facilities. In most of the cases, the standard operating procedures on different aspects of management were not properly documented. Therefore, during the survey, through small discussions the correct information was passed on to the hatchery operators to the extent possible.

6.3.3.14 Areas of Poor Practice

Table 6.16 Areas of Poor Practice

Observed Practices	Full C %	Min D %	Maj D %	Non C %
1. Inactive as well as those produced from spawns with hatching rate below 40% are rejected	0.00	7.14	21.43	71.43
2. The nauplii is stocked at a density of 100,000/ton	7.14	7.14	14.29	71.43
3. The larval rearing from N6 to PL3 is done for about 13 days	57.14	21.43	14.29	7.14
4. Shade clothes are provided over the tanks to prevent direct sunlight from entering the tanks	7.14	14.28	7.14	7.14
5. The post larvae are stocked at a density of 25-50/litre	57.14	14.28	14.29	14.29
6. Only healthy post larvae are reared further	50.00	7.14	14.29	28.57
7. Artemia, micro encapsulated diets and egg custard are given to the post larvae	71.43	14.29	7.14	7.14
8. The water sample is sent to a recognized laboratory for testing occasionally	14.28	21.43	28.57	35.72
9. Algae is fed after water exchange and in the evening at 3p.m	42.85	14.29	14.29	28.57
10. Compounded, hatchery made feeds are used as substitutes for supplementary feeds during periods of low demand and low selling price	57.14	7.14	14.29	21.43
11. The artemia cysts are stocked at a density of 1-2 gm/l	64.29	14.28	14.29	7.14

12. Weak seeds are separated before selling	50.00	28.57	14.29	7.14
13. The cost components are monitored regularly	64.28	7.14	14.29	14.29
14. The buyer and the price is prefixed	57.14	35.72	0.00	7.14
15. The residual chlorination is checked with the help of chlorine test kits	0.00	0.00	14.28	85.72
16. Records are kept regarding use of chemicals, daily checks and observations etc	0.00	14.29	57.14	28.57
17. The effluents are treated before discharge	28.57	14.28	35.72	21.43

Table 6.16 shows the areas of poor practice. Non compliance was noticed with respect to the practices such as stocking density, rearing and selling of seeds, testing water samples in recognized laboratories, treating the effluents before discharging, record keeping etc. Since the broodstock was very costly, the practice of rearing the entire batch of hatched out nauplii irrespective of the hatching rate was usual practice. The practice of stocking the nauplii brought from other states irrespective of their health status and without knowing their parental history was also prevalent. The conditions for rejecting or rearing nauplii have been indicated under paragraph 6.3.3.2. The practice of compensating the low selling price through the use of low cost feed was also noticed. This has to be viewed very seriously as the health and resistance power of the larvae could be affected which could also lead to future grow out failures. It is evident from Table 6.16 that the practices such as treating the effluents before discharging, testing the quality of influent water, discarding unhealthy seeds, maintaining optimum stocking density etc. are to be improved. Areas of improvement also include increased documentation on routine practices followed in the hatchery, larval culture history, certificates regarding use of feed, chemicals, etc.

6.3.4 Assessment of PRP Attitude

The attitude test was conducted to test the confidence, sense of responsibility, believes and expectations of the hatchery managers. The method described by Henroid and Sneed (2004) was followed for this part of the study. Table 6.17 shows that the mean attitude scores ranged from 2.50 to 4.64. The mean score obtained (3.07) for the statement on their responsibility regarding producing healthy and disease free larvae is to be viewed seriously and such an attitude was developed mainly because they themselves were not getting good quality, tested nauplii for rearing. The highest score, 4.64 obtained for the statement about the need for uniform fixation of the selling price indicates that just as the price of the nauplii ranges from Rs. 10000 to 18000 per million, the PL also were sold at a wide range of prices accordingly. Most of them disagreed on the statement regarding their obligation to properly feed and rear the larvae irrespective of the market price showing that feed substitution was a common practice to compensate for the low selling price. However, their knowledge about the role of low quality PL in causing crop failures was high. Most of them welcomed the requirement for training in good hatchery management practices (4.14%). The attitude regarding implementation of HACCP in shrimp hatcheries was almost neutral which may be because of lack of awareness about HACCP principles and application.

Table 6.17 PRP Attitude of hatchery operators

Statements	**Scale**	**mean**	**sd**
I am following good hatchery management	SA AN	4.35	0.63
practices	D SD	3.07	1.07
I am responsible for making sure that the larvae			
produced are healthy and disease free		4.64	0.92
I think that there is an urgent need for uniform			
fixation of the selling price		2.50	1.16
I have an obligation to properly feed and rear the			
larvae irrespective of the market price		4.57	0.64

I understand that the PL released can cause crop failures, if not healthy and safe		4.14	0.77
I would like to be trained in GHMP which I think would help me to do my job better		3.14	1.02
The implementation of HACCP is needed in shrimp hatcheries			

SA- Strongly agree, A - Agree, N - Neutral, D - Disagree, SD - Strongly disagree

6.3.5 Major Constraints faced by the hatchery operators

The hatchery operators who were selected for the HACCP and PRP study were contacted and asked to list and rank the problems faced by them according to the level of severity. Based on the responses the rank based quotient (RBQ) was calculated using standard procedures (Hogg and Craig 1995). RBQ is the weighted mean of ranks (1-worst to 10-best) with respective frequencies/ total frequency as weights. RBQ= sum(rank(i) * frequency of ith rank)/total frequency).

Table 6.18 Rank based quotients of major constraints in hatchery operations

Sl.No.	Major constraints	RBQ
1	Higher price for broodstock	0.96
2	Low survival of nauplii	0.89
3	Low/fluctuating selling price	0.88
4	Non availability/high cost of feed	0.84
5	Bad water quality	0.79
6	Lack of sufficient fund	0.78
7	Less demand	0.76
8	Non availability of technical assistance/training	0.66
9	Non awareness to maturation and spawning	0.51

It is evident from table 6.18 that higher price for broodstock was the most important problem confronting the hatchery operators. This constraint had a score of 0.96. Non availability was also equally existent. The price ranged from 5000 to 15000 which is the reason why the hatchery operators were procuring nauplii from other states especially from the east coast where it is easily and cheapily available. Usually the hatchery operators entrust the boat owners to bring ashore the gravid spawners as and when they get them. In such cases, the prices will be higher as the boat stops the days fishing to hand over the catch. In instances where the boat owners sell their occasional catch of spawners to the hatchery operators, the spawners may not be of the required quality, might be injured or mutilated and will get only lesser price. Sometimes, the spawner dies before spawning. Studies conducted by Samraj et al. (2007) on the health of wild broodstock (*P.monodon*) and the presence of MBV and WSV, through Shrimp Broodstock and Nauplii Rearing Centre (SBNRC) of Rajiv Gandhi Centre for Aquaculture (RGCA), revealed the prevalence of viral infection in wild broodstock and stated that production of nauplii by screening the broodstock would result in producing high health PL in hatcheries. Low survival of nauplii was identified as the second important problem (0.89). In fact, most of the hatchery operators were not highly experienced in the area of spawning and hatching. The low survival of nauplii could be mainly due to the bad health of the mother prawn. Some people attributed this to the bad water quality in the area, i.e, the water was too turbid and the super filtration needed for the nauplii care was not achievable. Low technical know how, bad water quality and the exhausted condition of the mother prawn etc. were the reasons understood. Low Selling price (0.88) was identified as the third important problem. The selling price of the PL ranged from 15 to 55 paise. At as low a selling price as 15 paise, the hatchery operators were selling the product on loss with the hope of making it up during the favourable season. Also, in order to compensate for the low selling price, they were substituting the nutritious and imported microencapsulated feed with low cost diet. Non availability of feed was the problem often faced by the Govt. hatcheries because of the delay in the release of funds at proper times. This constraint had a score of 0.84. During the periods of feed shortage, they were depending on compounded feed of egg custard, fish meal etc. Bad water quality was a problem many of the hatchery people were fed up of, which had a score of 0.79. The foot valve of the water pipes could not be kept in sufficient depth in some areas, the water due to high surf action was highly turbid in other areas and the water filtering system was not upto the mark in some cases. Lack of sufficient fund (0.78) was a problem often faced by the Govt. hatcheries. Even when available, it was not obtained at the proper time. Less demand (0.76) was cited as a problem by the hatcheries during the period May to August because of South West monsoon in Kerala during June to August. During such period, the price even went down to 15 paise per nauplii and most of the hatcheries were shut down during this period. Non availability of technical assistance was another draw back in the hatchery sector. This requirement had a score of 0.66. In the present study, during discussions most of the hatchery operators revealed that they welcome frequent monitoring or quality checks by the regulatory agencies mainly because they will get proper directions from experts in the field. Non awareness to maturation and spawning (0.51) was an area which many of the hatchery managers were unaware of. This may be because most of them were procuring the nauplii from other states like Tamil Nadu and were not familiar with the maturation and spawning techniques.

6.4 Discussion

In the present study, the shrimp hatchery operators were found to have a significant amount of knowledge in areas such as larval and post larval management, feed and water quality management. However, their knowledge in areas like broodstock management, recommended standards for the feed, influent and effluent water quality parameters, disease management, application, use and potential hazards of chemicals etc. was poor. Deviations from the recommended practices were noticed with respect to certain practices which have been discussed in paragraph 6.3.3.14. The practices of compensating low selling price through the use of low cost feeds as well as selling undersized and weak PL etc. were common. Several workers have studied the impact of dietary conditions on the overall physiological condition as well as stress resistance of the shrimp fry during early postlarval development (Lemos and Rodrguez 1998, Lavens and Sorgeloos 2000). The costs of formulated feed and labor associated with feeding are a major component of the cost of hatchery shrimp production. The practice of testing the feed for the nutritive content and other factors before use was also not prevalent.

Several studies have pointed out the need for the stress tests, which are rapid, inexpensive and simple, that can be used by shrimp hatcheries as a good reference for overall seed quality as well as a quality control procedure at earlier stages as a predictive quality criterion or at later stages as a final PL quality criterion (Samocha et al. 1998, Lee 2003, Racotta et al. 2004). While biochemical composition, survival from the stress tests, PL size etc. are recommended as indicators of physiological condition and overall larval performance, the present study observed that no such quality tests before sales were usually carried out except the visual examination and an acclimatization in the shrimp farm water. Most often, it was at the farmer's interest that the PCR test for PL was conducted before procurement. Studies show that it is the weaker and smaller PL which are most likely to be affected with diseases. Abundant supplies of high quality post larvae coupled with good farm management practices only will result in stable and sustainable production.

Poor cleaning and sanitizing practices like inadequate and improper handwashing, foot dipping and tank cleaning practices were observed in most hatcheries. The importance of cleaning and sanitizing practices in foodservice operations (Kang 2000, Walker and Jones 2002, Henroid and Sneed 2004) and hatcheries in particular (Karunasagar et al. 1998, Vaseeharan and Ramasamy 2003, Abraham and Palaniappan 2004) has been reported by several workers. Despite the efforts by the shrimp hatcheries to combat the problem of *V.harveyi* infections by adopting water treatment measures such as sand filters and chlorination, it has been observed that these organisms can be found in larval rearing tanks in considerable numbers, since this organism is a part of the autochthonous flora of the marine environment and hence present in the near shore waters (Karunasagar et al. 1998). Their study also noticed that bofilm formation occurred even in the presence of the antibiotics chloramphenicol and tetracycline, both added to the medium at 50 ppm and the results emphasized the need for physical removal of biofilm on tank surfaces and periodical drying of tanks to reduce the chances of infection by organisms such as *V. hurveyi.* Vandenberghe et al. (1998) studied the bacterial infections in *P.chinensis* larvae in Chinese shrimp hatcheries and observed that the flora associated with the larvae is not very stable and is influenced by the bacterial flora of the administered food and the environment. Vaseeharan and Ramasamy (2003) indicated that *Artemia* nauplii are one of the principal agents for transmission of pathogenic *Vibrio* spp. infections in post larval *P. monodon* and that these could originate from contaminated source sea water, live feed organism *Artemia* cysts, contaminated hatchery equipment and unhealthy infected post larvae.

The stocking density was noticed to be intensified during peak seasons. Studies have shown that this can be attributed as one of the reasons for the disease outbreaks occurring during peak seasons. In the present study, while discussions with the hatchery operators, many of them revealed that during peak seasons, owing to the practice of continuous stocking and overstocking, they experience shortage of tanks and vessels. During such periods, they are forced to limit the tank cleaning operations to the minimum possible level as well as often resort to overfeeding to facilitate fast growth of the larvae to accommodate the next batch. During the PRP survey also, 85.71% of the hatchery operators had admitted that they were facing failures during peak seasons. Hence, the present study suggests the need for written standard operating procedures with respect to proper sanitary and hygienic practices for strict compliance by the hatchery personnel in order to prevent disease outbreaks. These observations of poor cleaning and sanitizing practices are consistent with sanitizing practices observed in previously conducted studies in different countries (Walker et al. 2003, Bas et al. 2006). Vaseeharan and Ramasamy (2003) found that ineffective cleaning of hatching tanks in shrimp hatcheries could result in survival of *Vibrio* spp. and act as a source of contamination. Abraham and Palaniappan (2004) recommended that support measures such as water treatment, rinsing of artemia nauplii, physical removal of biofilm on tank surfaces, periodical drying of tanks etc. are essential for reducing the incidence of luminous vibriosis infection in shrimp hatcheries.

All these findings suggest the need for improvements in employee habits and sanitizing practices. The present study indicated that many of the hatchery operators had a poor knowledge with respect to cleaning and sanizing agents, other chemicals and drugs, their concentration and contact time. Several studies have pointed out the need for standardisation and safety of drugs used in hatcheries for protection of the environment and humans (Vaseeharan et al. 2005). There is need for educating the hatchery operators on the correct use of drugs and chemicals. Chloramphenicol and nitrofurans are banned for use in shrimp hatcheries and aquaculture. Even though banned, enforcement of such bans is weak and drug of choice is observed to be determined by cost and availability. It is at this juncture that the importance of implementing PRP and HACCP becomes significant. The main idea behind HACCP is that it is possible to identify potential hazards and faulty practices at an early stage in the production chain. In the measuring and recording category, measuring PH, temperature and salinity was frequently carried out, but the practice of recording was very poor. In hatcheries also, the practice of using certified and calibrated instruments, tool kits, test strips etc. for accurate measurements was not prevalent. These observations are consistent with the observations made by Bas et al. (2006) in food businesses where the practice of recording was very poor and Henroid and Sneed (2004) who observed difference in actual and measured values in the case of temperature measurements due to the inaccuracy of the instruments used for measuring. Sending water and PL samples to a recognized laboratory for PCR and other testing has been in practice over the past two three years. The record keeping practice was poor. Maintenance of hatchery management records is a good practice which helps the hatchery operators to plan their production as well as serves as a document of proof for following good hatchery management practices. The small scale shrimp farmer's habit of bargaining on shrimp seed prices ensured a permanent market for the hatchery produce, though at lower prices. Shrimp farmers are increasingly becoming aware of the safety risks of stocking virus affected larvae and so will demand guarantees regarding health and quality status of shrimp seeds in the near future. These trends suggest that meeting product safety and quality standards is becoming a challenge for the hatchery operators.

Therefore, the hatcheries should take utmost care in product handling and prevention of risks throughout the production process. The problems identified during the present study are non availability of good quality spawners and nauplii, low influent water quality, non certified feed, fertilizers and drugs, disease problems and lack of training. The dependence on wild broodstocks which determines the price, production and quality of seeds continues to be a significant bottleneck in hatchery technology (Browdy 1998). Similar situations were observed in the present study also. The environmental impacts of the wild shrimp spawners and seed fishery as well as the possibility of environmental degradation due to mass production of shrimp seed in hatcheries are threats faced by the hatcheries as documented by several authors (Primavera 1998, Islam et al. 2004). PCR tests are now increasingly employed for detection of WSSV in the broodstock and hatchery reared larvae. Some hatcheries have set up PCR labs also.

The shrimp hatcheries have already in place various practices including ingredient and product specifications, cleaning and disinfection regimes, hygienically designed facilities and are engaged in good hygienic practices. These conditions satisfy the requirements of WHO (1993) as pre requisites for effective implementation of HACCP. Taylor (2001) has indicated that small companies have little motivation for adoption of HACCP, largely due to their belief that they produce safe food already and the only pressure to apply HACCP for these companies have been from legislation. Government's role in developing food safety program is very important. In a country like ours, many farmers depend on a successful crop to be able to ensure livelihood of their households as well as shrimp is a high value export commodity. Developing and implementing written standard operating procedures is one of the first steps to build effective HACCP systems (Bas et al. 2006). Written standard operating procedures need to be supplied and implemented in shrimp hatchery operations. In addition, the significance of HACCP implementation needs to be clarified and emphasized since presence of PRP were identified. Maldonado et al. (2005) studied the costs, difficulties and benefits of HACCP implementation in the Mexican meat industry and found that investment in new equipment and microbiological tests of products accounted for most of the implementation and operational costs respectively. In the present study, the managers revealed that they were afraid of the additional paper work and also that they will be overburdened with frequent inspections by the regulatory officials. Similar observations have been made by Taylor (2001). In small companies, verbal communication plays the major role and paper work of any kind is considered as a burden (Taylor 2001). Taylor and Kane (2005) indicated that documentation and record keeping overburden most of the HACCP systems investigated.

The efficiency of the hatchery production can be improved through the use of better quality nauplii, sticking on to optimum stocking density, improved management of water and feed, optimum usage of chemicals, etc. Management of hatchery water quality, PL production process, feed and chemicals management and many other areas can be addressed through the implementation of PRP which has been discussed in paragraphs 8.3.1.1 to 8.3.16 in chapter 8. Overall results indicated that PRP awareness of the hatchery operators was satisfactory and proper pre requisite shrimp hatchery practices were often followed in most of the hatcheries studied. However, this was never named or identified by them as PRPs for HACCP. Since, most of the hatchery operators presently have limited understanding of the PRP and HACCP strategy, substantive training should be provided. The findings of this study have indicated that most of the hatchery operators have not received any basic training in PRP and HACCP. Training is one of the PRP and should be a priority for the hatchery operators because many researchers have pointed out that the success of a HACCP program depends on the education and training of employees on the importance of their role in maintaining food safety. The need for training of personnel in the industry for the effective implementation of HACCP has been pointed out (CAC 1997, NACMCF 1998). Proper understanding of HACCP and the related PRP by the hatchery operators as well as a commitment from the regulators and the Govt. is required to make HACCP implementation in the hatcheries successful.

Several studies have examined the barriers to HACCP implementation in food businesses (Henroid and Sneed 2004, Bas et al. 2006) and have been identified as inadequate equipment and physical conditions of the facility, employee and resource barriers, employee motivation and record-keeping. Bas et al. (2007) in a study found that managers seemed to find it difficult to make their employees understand the importance of hazard analysis and why particular operations had to be monitored and controlled. But, in the present study, the managers themselves seemed to find it difficult to understand the importance of hazard analysis. The main constraints to HACCP implementation perceived by the hatchery operators were lack of motivation, lack of training, lack of technical and financial support. In a study conducted in Madrid to identify the barriers which are obstructing the implementation of HACCP programs in food companies, Vela and Fernandez (2003) noticed that lack of understanding and negative guideline factors often resulted in inadequate hazard analysis and suggested that it was problems at attitude level that obstructed the change of behavior and so regulatory agencies should work to publish clear and detailed HACCP and pre requisite guidelines in vernacular languages to promote better understanding. In the present study, it was noticed that language was not a barrier for the hatchery personnel when compared to the shrimp farmers, but, the real fact is that even though guidelines on PRP as well as HACCP consultants are available, guidelines or publications and training programs, connecting and clearly specifying the relation between these two concepts and how HACCP and PRP can co-exist in a system and support each other, is rare or nil and not available. The findings of the present study is expected to eliminate such confusions and the quality and safety model described in chapter 8 shows how these two concepts are inter connected, controls the various activities in a hatchery production process, which is easily understandable and self explanatory to a good extent.

6.5 Conclusion

Overall results indicated that PRP awareness of the hatchery operators was satisfactory and proper pre requisite shrimp hatchery practices were often followed in most of the hatcheries studied. While the feeding regime is documented to have a direct bearing on the quality of PL raised, the present study noticed that practices such as low priced feed mixing, malnutrition, underfeeding, overfeeding, etc. were usual according to the market price and demand. So there is need for research work on optimum nutrition and health management in hatcheries. Though, presently we have well documented quality specifications for shrimp post larvae stipulated by AAI, these specifications remain ignored by the hatchery operators for want of enforcement of regulations and unquestioned by the end users due to the ignorance of the shrimp farmers. The practices of continuous stocking and overstocking often results in poor cleaning and sanitizing practices inviting disease outbreaks during peak seasons. Of these, the practices of compensating the low selling price through the use of low quality feeds, continuous and overstocking of nauplii as well as selling undersized and weak PL etc. are to be viewed seriously and need immediate regulatory attention.

There is need for ensuring the quality and safety of the hatchery seeds thereby protecting the farmers from economic fraud while ensuring a reasonable prize to the hatchery owner for the PL produced. The record keeping practice has to be improved. The present study suggests the need for written standard operating procedures with respect to proper sanitary and hygienic practices for strict compliance by the hatchery personnel in order to prevent disease outbreaks. Compared to the shrimp farmers, the awareness of the hatchery operators was higher with respect to information on HACCP and PRP. There is some sort of order and system prevailing in the hatcheries which when coupled with the easiness to access and being limited in number for facilitating verification and audit, paves way for effective HACCP and PRP implementation in hatcheries. Results of this study can be used to develop programs for implementing HACCP procedures and related PRP in shrimp hatcheries. In the light of the anticipated economic, regulatory and environmental pressures on the industry, it is high time that the hatchery operators be prepared for voluntary adoption of better management approaches.

xxx

Chapter-7

DEVELOPMENT OF SAFETY AND QUALITY MANAGEMENT MODEL FOR IMPLEMENTATION IN SHRIMP FARMING OPERATIONS

7.1 Introduction

Food safety issues are becoming more important in international trade (WHO 1998). In food production, where the safety of the produced food has the ultimate priority in the framework of quality, the HACCP system is the internationally recognized system to help assure safe food production (Blaha 1999). HACCP's preventive focus is seen as more cost-effective than testing a product and then destroying or reworking it (ICMSF 1988). The HACCP system has been used by private firms since the 1960s, but during the 1990s, the public sector adapted the concept for food safety regulation and has been mandated by government regulation for some part of the food system in the EU, US and many other countries (Unnevehr and Jensen 1999). Martin and Anderson (2000) noticed the growing adoption of management practices in the food industry that focus on prevention and control of food safety hazards. The concept and principles regarding HACCP have been presented by Sperber (1991a), Bryan (1992) and NACMCF (1992). Several workers have outlined the role of farm to table approaches and HACCP in ensuring safety in different fields (Bryan 1992, Motarjemi et al. 1996, Sperber 2005b) and the resulting public and private actions needed to guarantee safety (Unnevehr 2000). Farm to table process control to manage both quality and safety is increasingly in demand in high income markets, and new institutions are evolving to certify production practices (Unnevehr et al. 1999). Consumers in high income countries have become more aware of food safety risks and demand greater guarantees regarding product handling. At the same time, many developed countries are modifying their food safety regulations to emphasize process control and prevention of risks throughout the production process. These trends mean that meeting food safety standards is a challenge for food product exporters (Unnevehr 2000). The HACCP combines commonsense, with an evaluation of risks, to identify the points along the food production chain where possible hazards may occur, and then to strictly manage and monitor these points to make sure the process is in control (Blaha 1999) and even as far as serving based on controlling time, temperature, and specific factors that are known to contribute to foodborne disease outbreaks (McSwane et al. 2003). Panisello and Quantick (2001) indicated that food safety is achieved using different types of HACCP programs, representing the diversity of industries, countries and people managing the safety of food stuffs, throughout the world and that the HACCP plans are tailor made and fit within the necessities and capabilities of every industry sector. The HACCP system in manufacturing plants differs from the HACCP system in the foodservice areas due to the time, procedures and hazards involved (Sun and Ockerman 2005). Several workers suggested the need to have a more flexible HACCP system in foodservice operations (Seward 2000, Sun and Ockerman 2005). It is not HACCP system itself which makes food safe, but its correct application (Motarjemi and Koaferstein 1999). Several researchers have pointed out that formal PRP are needed to support the implementation of HACCP (Seward 2000, Mortimore 2001, Wallace and Williams 2001, Walker and Jones 2002, Henroid and Sneed 2004). More recently, there has been a growing awareness of the importance of an integrated, multidisciplinary approach to food safety and quality throughout the entire food chain (Ababouch 2006, Bertolini et al. 2006). Even though a good amount of literature is available projecting the role of HACCP as a food safety assurance system and PRP as a support system for HACCP, reports highlighting the importance of an integrated approach to food safety and quality, by combining the concepts of HACCP and PRP, are not many (Mortimore and Wallace1998, Ababouch 2000, Mortimore 2001, Wallace and Williams 2001). Integration of HACCP systems into the quality management systems (Mortimore and Wallace1998, Mortimore 2001) such as the ISO 9000 series (Wallace and Williams 2001) has been suggested. Mortimore and Wallace (1998) described PRP as the HACCP support network and designed a model which shows the inter-relationship of management systems and procedures in any food business for the production of safe, high quality products. Mortimore (2000) proposed a useful scheme to help differentiate between different types of control points which demonstrates that the term CCP should be kept for food safety management. Wallace and Williams (2001) observed that it is possible that a company may develop both HACCP and PRP systems, yet fail to link the two systems together. In such situations there is chance that the issues may either be missed or duplicated (Sperber 2005b). A few workers have pointed out that there is a big confusion between PRP and HACCP plan, their relations and how they should be managed. This gets worse because there is a lack of specific hazard analysis and the reasons for this misunderstanding are located on negative guideline factors and lack of understanding, being difficult to say which barrier takes place first (Vela and Fernandez 2003). Similar observations have been made in the present study also while conducting the HACCP and PRP surveys discussed in Chapter (4). A review of food safety literature and discussions with the shrimp farmers and others regarding hazard analysis urged the need for a model which could guide the farmers and the HACCP practitioners through the HACCP process. Many researchers have pointed out the importance of an integrated, multidisciplinary approach to food safety and quality and so managing both HACCP and PRP within a quality management system, has been tried out in this study. A model has been designed, by consolidating various concepts from similar models (Mortimore and Wallace1998, Mortimore 2000, Griffith 2001, Mortimore 2001, Wallace and

Williams 2001) which can be adopted as a generic model for safety and quality management in shrimp farming operations.

7.2 Methodology

As discussed in Chapter 3.2

7.2.1 PRP Assessment of Farm Layout and Facilities

The same shrimp farms and farmers selected for the HACCP principles adherence and PRP study were selected for the PRP evaluation. As part of the PRP assessment, an evaluation of the facilities including equipment, structure of premises, waste, cleaning, personal hygiene and pest control etc. was done and details regarding farm layout was collected to identify potential points of contamination.

7.3 Results and Discussion

7.3.1 The prerequisite programs in shrimp farming

The HACCP system within the food processing industry focuses on the overall process from growth and harvest to product utilization and establishes an assessment of the risk of occurrence of specific hazards and how these can be functionally controlled at specific points throughout the process (Sperber 1991a). The WHO defines PRP as 'the practices and conditions needed prior to and during the implementation of HACCP and which are essential for food safety' (WHO 1993). The concepts of PRP and how it will benefit HACCP had been reported by many workers (Wallace and Williams 2001). FDA emphasized the role of PRP for the implementation of HACCP (Griffith 2000). Several authors have opined that PRP is important and should be in place before HACCP is established (Seward 2000, Sun and Ockerman 2005). Walker and Jones (2002) suggested that the establishment of PRP could provide a solid foundation to develop HACCP. If the PRP are not used, there will be a waste of resources and money and might cause more resistance for future utilization and HACCP system implementation. PRP, which support HACCP plan, also called standard operating procedures (SOP), includes good personal hygiene (employee hygiene practice), cleaning and sanitation programs (environmental hygiene practice), proper facility-design practices, equipment-maintenance, and supplier selection and specification programs (cross-contamination control) (National Restaurant Association Educational Foundation, 2002). According to Wallace and Williams (2001), the concept of PRP has been evolved from the concept of GMP which have been employed by the food industry for many years. They point out that the PRP include elements such as cleaning, operator and environmental hygiene, plant and building design and preventive maintenance, previously and still frequently described as GMP. Mortimore and Wallace (1998) described PRP as the HACCP support network (Fig.7.1) which shows the inter relationship of management systems and procedures in any food business for the production of safe, high quality products.

The PRP in a shrimp farming operation cover all those activities which interact within and across various processes that may influence the final safety outcome of the shrimp raised. The aquaculture production of shrimp may pose a threat to public health if they are not grown and harvested under strictly hygienic and safe conditions (Suwanrangsi et al.1997). In the present study, the quality and hygiene hazards which may arise from the processing and surrounding environment were separated to be addressed through the PRP. The PRP identified for a shrimp farm were the following: Site Selection, farm design and construction, pond preparation, seed quality and stocking, water and soil quality management, shrimp health management, feed, fertilizers, drugs and chemicals, pond sediment and effluent management, harvest and post harvest management, social and community relations, transportation, prevention of cross contamination, training, pest control and on-farm testing facilities. The PRP were identified based on the guidelines formulated by Suwanrangsi et al. (1997), AAI (2002), MPEDA/NACA (2003), Ravichandran and Pillai (2004), GESAMP (2005) and Subasinghe (2005).

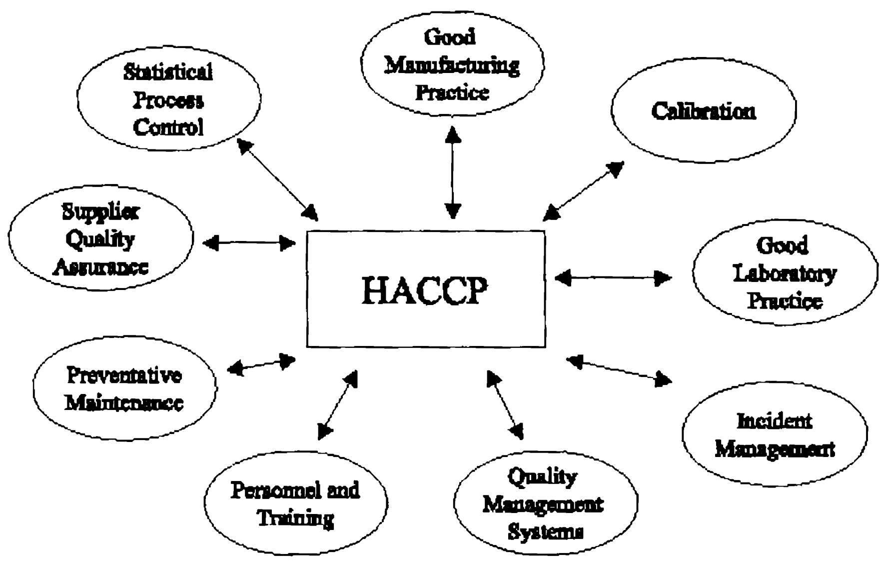

Fig 7.1 The HACCP Support Network from Mortimore and Wallace (1998).

7.3.1.1 Site Selection

Several studies have recommended the use of Geographic Information System (GIS) in aquaculture site selection from different parts of the world (Giap et al. 2005, Rajitha et al. 2007). Karthik et al. (2005) recommended the use of Geographic Information System in brackishwater aquaculture site selection from Maharashtra, in India. A good site saves the shrimp farmer from many problems that may arise at a later stage. A thorough check of the soil and water quality, hydro-meteorological characteristics- rainfall, tidal fluctuations, flood levels etc. should be conducted before site selection and farm design. Areas prohibited for conversion into shrimp farms such as mangrove forests, agricultural lands, saltpan lands, ecologically sensitive areas like sanctuaries, marine parks etc. should be avoided. The criteria for good site selection for aquaculture have been reported (Primavera 2006). Drawal of groundwater for shrimp farming is strictly prohibited. Prior approval from the Aquaculture Authority is mandatory and the norms stipulated by the Authority should be adhered to while setting up and operating the farms. The quality of soil should be ascertained for pH, permeability, bearing capacity and important nutrients. The water should be of high quality and the water source should be free from industrial and agricultural pollution (AAI, 2002).

7.3.1.2 Farm Design and Construction

A good farm design can avoid problems related to flood levels, storms, erosion, seepage, water intake and discharge. The parameters like tidal amplitude, water current, wind direction, wave action, past history of flooding during cyclones or storms etc. should be taken into consideration while designing embankments. Reservoir ponds are necessary in areas where highly turbid water is available as well as overcrowding of farms occurs and intake and outfall are from the same source (AAI, 2002).

7.3.1.3 Pond Preparation

Pond preparation can be done through drying, tilling and ploughing. The pond should carry a minimum water depth of 80-100cm, the sluice gates should be watertight and provided with net filters (AAI, 2002). Removal of pests and predators, application of disinfectants and lime, enhancement of nutrient levels in water through manuring and fertilization, maintenance of optimum phytoplankton growth etc. are important points to be taken into account during pond preparation. The risk factors associated with pond preparation and the management guidelines are detailed (MPEDA/NACA 2003, Subasinghe, 2005).

7.3.1.4 Seed Quality and Stocking

As seed quality largely determines the survival and growth of farmed shrimps, only hatchery reared and healthy seed should be used. Stocking densities of upto 6nos/ sq.m are permitted in ponds within the CRZ and upto 10nos/ sq.m outside the CRZ. The seed should be acclimatized to the prevailing temperature, salinity and PH in the pond and should be done at the hatchery itself before stocking (AAI, 2002).

The risk of disease in shrimp farming often increases with culture intensity and high stocking densities (Kautsky et al. 2000).

7.3.1.5 Water and Soil Quality Management

Several reports point out that the water quality standards should apply equally to influent water in ponds as to drainage waters flushed into adjoining estuarine and marine habitats (Primavera 2006). Good water exchange keeps the solid wastes and metabolites within tolerable limits. Nutrients and organic wastes in shrimp farms consists of solid atter(uneaten food, faecal matter, phytoplankton) and dissolved metabolites(ammonia, phosphate, carbon dioxide, nitrite and nitrate). If water quality remains within optimal limits, no water exchange is required for the first two months of rearing. While exchanging water, care should be taken to avoid wide fluctuations in water quality conditions, proper screens should be used to prevent the entry of pests and predators as well as release of cultured shrimp (AAI, 2002). The shrimp farm water quality parameters have been studied by several workers (Smith et al. 2002, Abraham et al. 2004, Arnold 2006). Water used for shrimp farming should conform to the quality requirements specified in respect of organoleptic, physico-chemical, toxic constituents and bacteriological parameters.

7.3.1.6 Feed Quality and its Management

Good quality feed and its management are essential for sustainable and economical shrimp farming. Feed management practices should ensure the optimum use of supplementary feed by regulating the use based on the results of feeding check trays placed in the pond. Pellet feeds which leads to optimum growth of shrimps and reduced nutrient enrichment of wastewater should be used which should be properly stored in cool, dry areas and not for more than a few months. Feeding of uncooked organisms such as fish and invertebrates should be avoided. Farmers should keep records of daily feed application (AAI, 2002, MPEDA/NACA, 2003, Subasinghe 2005). The feeds should be tested before or after purchasing. The feed should be nutritionally adequate water stable (Smith et al. 2002).

7.3.1.7 Shrimp Health Management

Management of pond environment and water quality are of utmost importance in disease prevention and control. Primavera (2006) is of the opinion that the control of diseases and pests through the use of chemicals should be a last resort only after environmental onditions, nutrition and hygiene have been optimized. Inactive and sluggish, empty gut, blue or black colouration, body blisters, flared up gills, broken appendages, coloured gills, opaque muscles etc. are symptoms of diseased prawns. Healthy PL should be used and the pond farm environment should be routinely monitored for disease. In case disease outbreak occurs, care should be taken to prevent the horizontal spread of disease. Banned chemicals and drugs should not be used and all the treatments should be carried out in accordance with the recommended practices and comply with all national and international regulations (AAI, 2002). Studies conducted by MPEDA/NACA (2003) revealed that changes in color of pond water, blackening of pond bottom and shrimp coming to pond edges and increasing number of weak or dead shrimp etc.are indicative of disease outbreaks.

7.3.1.8 Use of Antibiotics and Other Chemicals

Graslund et al. (2003) have studied the chemicals and biological products used by the shrimp farmers in Thailand. and found that many of these pesticides, disinfectants and antibiotics used by the farmers could have negative effects on the cultured shrimps, cause a risk for food safety, occupational health, and/or have negative effects on adjacent ecosystems. Most substances used in pond aquaculture to improve soil or water quality present little or no risk to food safety (Boyd and Massaut 1999). The most common substances used in pond aquaculture are fertilizers and liming materials. Fertilizers are highly soluble and release nutrients that can cause eutrophication of natural waters. Liming materials do not cause environmental problems, and liming and inorganic fertilizer compounds do not present food safety concerns. Other substances used less frequently in aquaculture including: oxidants, disinfectants, osmoregulators, algicides, coagulants, herbicides, and probiotics quickly degrade or precipitate. They are not bioaccumulative and do not cause environmental perturbations in natural waters receiving pond effluents. However, there is potential for some chemical compounds used in shrimp culture to pose health risks to farm workers. Therefore, proper training and provision of adequate safety precautions is essential.

7.3.1.9 Pond Sediment and Waste Water Management

Several researchers have pointed out the importance of water quality management and potential environmental impacts caused by wastes discharged from shrimp farms (Montoya 2000, Stanley 2000, Boyd 2003). It is recommended to dry the ponds between harvests rather than removing sediment accumulations from the bottom. Wastewater can be used by way of bioremediation for secondary aquaculture or should be directed to settlement ponds. The wastewater should be discharged into receiving water bodies only after checking the water quality parameters. In areas where the tidal current is swift and the tidal amplitude is high, the waste water from the farm can be directly let out during the low tide whereas where the current is low, the wastewater should be treated in settling ponds before release into the natural system (AAI, 2002). Silviera et al. (2004) studied the coastal water quality and pointed out that sustainable coastal zone management include an efficient water quality program for each area or zone incorporating physical, chemical and biological measurements. It is necessary for a cluster of farms in an area to have common wastewater treatment systems and it is mandatory for larger farms above 5ha to have settling ponds.

7.3.1.10 Harvest and Post Harvest

Harvesting should be done by completely draining the pond either by gravity or by pumping and hand picking or trapping. The water drained out for harvesting should be directed to waste stabilization ponds before being released into open waters. Immediately after harvest, the catch should be washed in potable water, sorted and iced (AAI, 2002).

7.3.1.11 Social and community relations

It has been specified in the AAI guidelines (2002) that the shrimp farmers should ensure that the interests of the public in the area are safeguarded, access to the seafront and other common water resources are not obstructed, natural drainage canals which are used as water source for shrimp farms are not blocked etc. Primavera (2006) suggests approaches such as holistic integrated coastal zone management based on stakeholder needs, mechanisms for conflict resolution, assimilative capacity of the environment, protection of community resources, and rehabilitation of degraded habitats, to improvements in the aquaculture sector pertaining to management of feed, water, and effluents as for overcoming the impacts of aquaculture on the coastal zone. Shrimp farmers should form co-operatives, self-help groups or associations to exchange technology and achieve co-operation in water use and waste management. The farmers adopting BMPs recorded significant benefits from adopting BMPs and the 'aquaclub' formation (Padiyar et al. 2003). The farmer groups can play a very important role in managing the source water quality and the local environment (MPEDA/NACA, 2003).

7.3.1.12 Training

Several authors have suggested that the success of a HACCP programme depends on the education and training of the employees on the importance of their role in maintaining food safety (Bas et al. 2006). The farmers should have the necessary knowledge, skills ad aptitude for coducting shrimp farming on a scientific basis to facilitate implementation of GAP in shrimp farming. Therefore, there needs to be training and education about PRP and HACCP.

7.3.1.13 Transportation

The harvested shrimp should be kept under chilled condition and transported in insulated or refrigerated containers.

7.3.1.14 Fertilizers

Fertilizers are highly soluble and release nutrients that can cause eutrophication of natural waters. Boyd and Massaut (1999) reported that inorganic fertilizers do not present food safety concerns. A mixture of organic and inorganic fertilizers should be added to maintain a stable bloom. Organic manures should be used for promoting the growth of food organisms as far as possible in shrimp farms in order to avoid nutrient enrichment in receiving waters and the cowdung should be dried or tested. If the bloom is very dense, then water exchange should be carried out (MPEDA/NACA, 2003). Fertilizers should be added in split dosages for bloom maintenance and should be reduced or stopped during later stages of culture when the pond gets nutrients mainly from waste feed and shrimp excreta.

7.3.1.15 On-farm testing facilities

There should be provisions for checking the water transparency, P^H, color, temperature, alkalinity etc. on the farm site. The checking time and recommended values have been indicated (MPEDA/NACA, 2003).

7.3.1.16 Prevention of cross contamination

During periods of disease outbreak, surrounding farmers should try to avoid water exchange and should not use any equipment, nets, pumps, boats, tanks etc. from affected farms to prevent cross contamination from one farm to the other (MPEDA/NACA, 2003). Practices such as removal and safe disposal of sick or dead shrimp, emergency harvesting after proper decision making and no draining or abandoning of disease affected stocks etc. were recommended (Subasinghe 2005).

7.3.1.17 Pest control

The water inlets should be screened (60holes/inch) to prevent entry of virus carriers, predators and competitors for shrimp. There is also possibility of birds entering for taking shrimp. This should also be prevented by using proper frightening devices (MPEDA/NACA 2003).

7.4 Development of prerequisite programs in shrimp farming

HACCP is not a stand-alone system-it is supported by other programs that are increasingly becoming known as PRP (NACMCF 1997). This study identifies the above mentioned practices (7.3.1.1 to 7.3.1.17) as PRP for the shrimp farming operations and is illustrated in Fig.7.2. Before developing an HACCP plan for a production procedure, the establishment of SOPs and GMPs (PRP) is indispensable (Blaha 1999). Vela and Fernandez (2003) noticed an enormous number of CCPs (up to 253) in the HACCP plans evaluated and opined that most of these should not be considered as CCP's and that PRP are essential to build solid self-control system. PRP are found to be very effective in prioritising activities in certain factories in less developed countries and can be a useful starting point with companies who have a longer way to go to achieve HACCP. Several workers observed that PRP provides a solid foundation to develop HACCP and that there is need to implement PRP before they can be ready for HACCP implementation (Bas et al. 2006, Henroid and Sneed 2004).

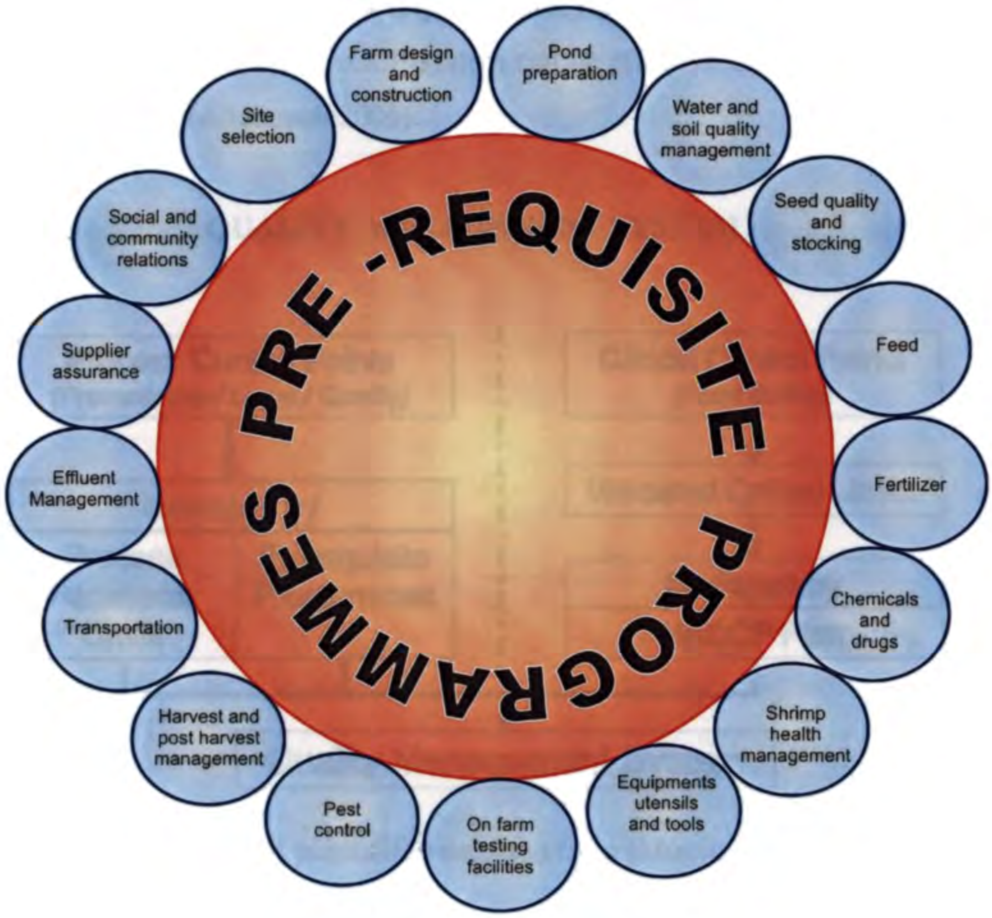

Fig.7.2: The Pre Requisite Programmes for a Shrimp farm

7.5 Differentiation of Quality and Hygiene Issues

Several researchers have pointed out that HACCP only has CCPs (Mortimore and Wallace1998, Wallace and Williams 2001, Sperber 2005b). Therefore, the key issue is to differentiate between the CCP which controls the significant food safety hazards and all other controls (Mortimore and Wallace1998). A misunderstanding exists and often the difference between CPs and CCPs is not well understood (Taylor 2001). Taylor and Kane (2005) observed that clarification of the role of Good hygienic practices (GHP) in food safety will reduce the number of CCPs dramatically by identifying correctly the few real CCPs and lead to a sophisticated understanding of HACCP. Several researchers have opined that PRP are needed in preparation for HACCP (Henroid and Sneed 2004, Bas et al. 2006). An HACCP system can be effective only if it is based on sound GMP/GHP (Ababouch 2006).

QUALITY MANAGEMENT SYSTEM

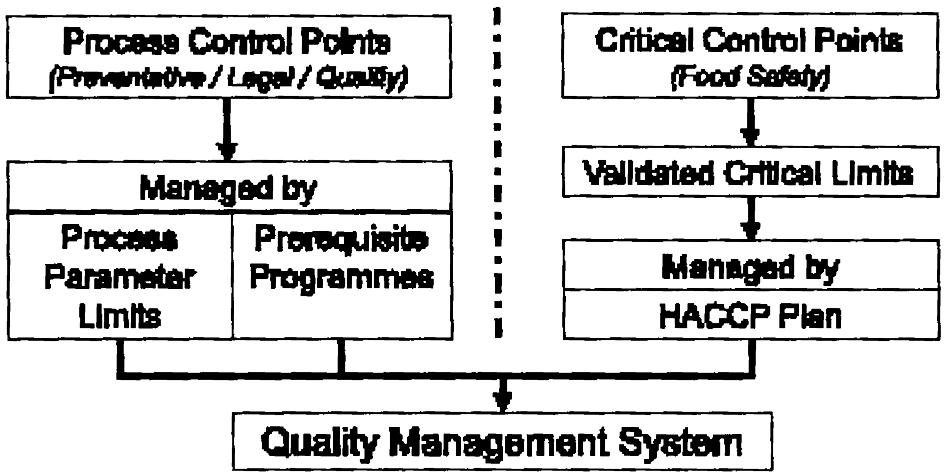

Fig 7.3. Control point differentiation from (Mortimore, 2000).

According to Wallace and Williams (2001), the inclusion of quality and hygiene issues in HACCP plans will lead to the over complication of HACCP and the accepted approach is to control significant hazards with the HACCP plan and to keep generalized GMP/GHP issues to the PRP where they are less likely to cloud the HACCP plan or divert attention from the essential controls, the CCPs. Mortimore (2000) is of the view that inclusion of CCPs in HACCP which are not true CCPs can cause major problems in practice and the quality management system model designed takes into consideration all the controlling points, the safety hazards addressed through the HACCP system and the quality and hygiene issues met with through the PRP (Fig.7.3). Therefore, an attempt is made hereby to the differentiation of quality and hygiene issues related with the PRP (Table 7.1).

Table 7.1: Differentiation of Quality and hygiene issues

Site selection	GMP (Good manufacturing practices)
Farm Design and Construction	GMP (Good manufacturing practices)
Pond Preparation	GMP (Good manufacturing practices)
Seed quality and Stocking,	GMP (Good manufacturing practices)
Water and Soil quality Management	GMP (Good manufacturing practices)
Shrimp Health Management	GMP (Good manufacturing practices)
Feed	GMP (Good manufacturing practices)
Fertilizers	GMP (Good manufacturing practices)
Drugs and Chemicals	GMP (Good manufacturing practices)
Pond Sediment and effluent management	GHP (Good hygienic practices)
Harvest and Post Harvest management	GHP (Good hygienic practices)
Social and community relations	GMP (Good manufacturing practices)
Transportation	GHP (Good hygienic practices)
On-farm testing facilities	GLP (Good laboratory practices)
Prevention of cross contamination	GHP (Good hygienic practices)
Pest control	GMP (Good manufacturing practices)

7.6 <u>The Process Control</u>

Several researchers have pointed out that preparation of flow charts and recording on worksheets are the basic procedures to be considered before implementation of HACCP (Bryan 1981, Seward 2000). Soriano et al. (2002) has provided detailed examples of processing flow charts and HACCP worksheets for cooked food items. According to McSwane et al. (2003), for HACCP application, the first task is to find the hazard locations and list them on the flow chart and then determine the CCPs. HACCP program need to be established for each food product preparation and this should contain the flow chart as well as standard operation procedures that need to be accomplished, type of hazards (physical, chemical or biological), control methods, control limits, monitoring frequency and documentation, corrective actions when limits are exceeded, and the personnel who is responsible (Soriano et al. 2002). Generic flow diagram for catering operations with SOPs (standard operating procedures) and CCPs (critical control point) proposed by Griffith (2000) is illustrated in Fig.7.4. To establish a HACCP program that will assist in producing safer products, procedures like finding the possible CCPs and the control limits, monitoring the CCPs and taking corrective actions if problems occur (in case of deviations from CCPs), and then validating the HACCP plan and keeping records to document on HACCP worksheets are essential (Sun and Ockerman 2005).

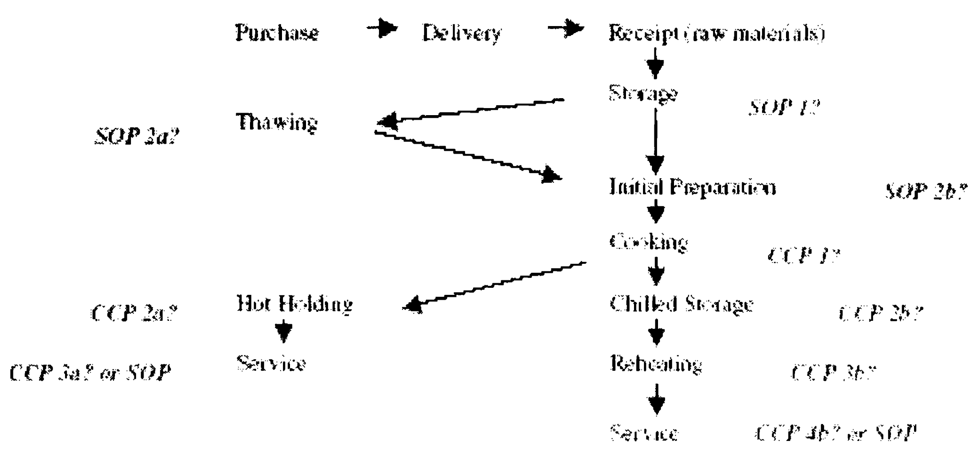

Fig.7.4. Generic flow diagram for catering operations with possible SOPs and CCPs from Griffith (2000).

7.6.1 Process flow chart

The development and control of HACCP systems is aided by a clear vision of the complex sets of relationships, processes and flows involved. The use of flow charts would help considerably in the exploration of issues of potential or actual process or product failure (Taylor and Kane 2005).

The present study identified all the specific steps involved in the production process, from the preparation of the pond bottom until the transportation of the harvested shrimp and is shown in the flow chart (Table 7.2). This process flow chart is an important aid to hazard analysis, assisting in identifying the steps where hazards are introduced or become a potential problem and in documenting all the major steps in an aquaculture operation. This study identified nine steps in the production process. The process starts with the preparation of the pond bottom. The pond bottom should be ploughed, the sludge removed, dried and compacted. The soil may contain Predators, competitors, benthic algae. disease carriers and organic load as left outs of the previous crop. Ploughing on wet soil is the recommended practice and compaction of the bottom is necessary after ploughing and drying in order to avoid turbid water conditions during water filling and subsequent culture. Next step is the disinfection and liming followed by filling water. The effectiveness of the disinfectant may be reduced if liming is done first. Also, in the case of acid sulfate soil, liming after water filling is the recommended practice. Fertilization of the pond is the third step after which the pond is ready for stocking. Fertilizers should be applied at least ten days before the planned stocking date so as to obtain a good plankton bloom with green color water. Selection of seeds is identified as a CCP. The condition and size of the seeds at receiving should be as per guidelines. PCR tested, virus free seeds are recommended for use for farming. This is for avoiding the possibility of WSSV outbreak. Longer transportation times may increase stress and cause mortality of the seeds. Weak seeds should be eliminated before stocking. Poor quality seeds and seeds below recommended size should not be stocked. The formalin treatment is helpful in reducing external parasites and fouling. The culture period usually lasts for 75-120 days. Good water quality management and feed management practices are essential to maintain a healthy environment within the pond. The feed is considered as a CCP, because the feed may contain antibiotics. So, in the case of organic shrimp farming, the feed need not be taken as a CCP. Shrimp health should be regularly monitored. Shrimps should be sampled once in a week by cast netting and should be checked for their behavior and feeding trends, general health conditions like external appearance, body color, missing appendages, gill color, fouling , gut condition and growth in terms of weight or length etc.and recorded. The next stages include Harvest, post harvest handling, storage and transportation respectively. The water used for washing the catch and ice making should be potable. The utensils and food contact surfaces should be cleaned and disinfected. The catch should be iced in the ratio 1:1 kept in chilled condition.

Table 7.2. Flow chart for the production of aquacultured shrimp

Step 1	The pond bottom is ploughed, the sludge removed, dried and compacted
Step 2	Pond disinfected, Limed and filled with water
Step 3	Fertilization of pond water
Step 4	Seeds are selected and transported to the farm site
Step 5	Seeds are transferred to plastic tanks, acclimatized,weak seeds eliminated and stocked
Step 6	cultured for about 75-120 days
Step 7	Harvesting
Step 8	Sorting, Washing and Icing
Step 9	Storage and Transportation

Fig.7.5 is an example of a flow chart, the generic aquaculture process flow chart prepared by Suwanrangsi et al. (1997). In this flow chart, four CCPs are shown; water, pond management, drug or chemical and pond condition. But, in the present study, only two CCPs were identified, one at the seed selection step and the other at the feed management step. So this study disagrees with Suwanrangsi et al. (1997) in the number of CCPs as well as the control points at which these CCPs are mentioned to occur. It is suggested that in the study by Suwanrangsi et al. (1997), only one true CCP is there, i.e, the drug or chemical. All the other CCPs mentioned (water, pond management and pond condition) are not true CCPs and can very well be controlled by the pre requisites (PRPs). An important omission is also noticed. The seed selection process, which is a CCP, was not identified. The omission of true CCP and the inclusion of CPs as CCPS is a clear indication of deviation from the essence of the HACCP plan. Sperber

(2005b) has opined that ignorance of HACCP often results in prerequisite programs getting confused with CCPs.

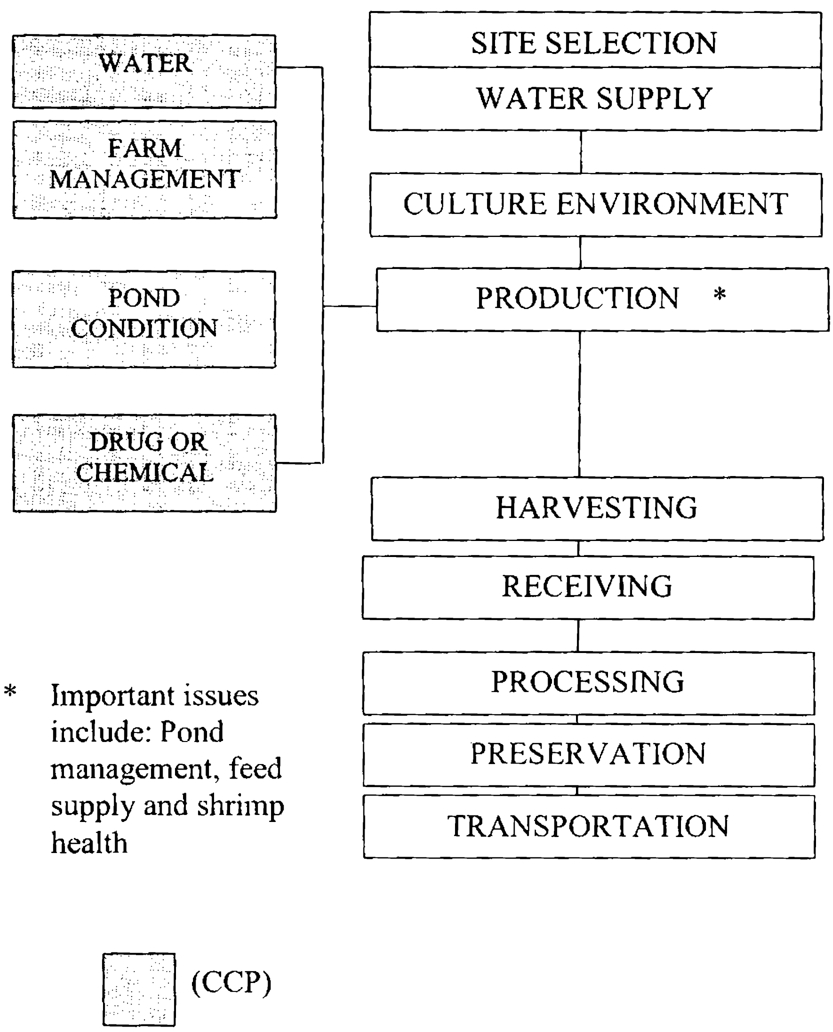

Fig.7.5 Generic Aquaculture Process Flow Chart from Suwanrangsi et al. 1997)

7.6.2 Hazard Analysis

A good hazard analysis is essential to obtain an efficient HACCP plan, but it is common to declare the hygiene measures as a HACCP concept without carrying out a specific hazard analysis (Panisello et al.1999, Untermann 1999). Many hazards are expensive to test for and may enter food products at several points in the production process. While testing and verification are essential for establishing good process controls, testing can never be practical as the only means of monitoring safety. Therefore, documented production practices, that are verified to prevent and control hazards, are becoming accepted as the most cost-effective means of reducing food safety hazards (Unnevehr 2000). According to several authors, the HACCP system is made up of three parts, viz, identification of hazards, determination of critical control points (CCP) and establishment of monitoring procedures.

7.6.2.1 The identification of Hazards

A 'hazard' is a biological, chemical or physical agent in, or condition of food, with the potential to cause an adverse health effect (Codex 1997). Hazards can be things that cause harm (Griffith 2000), and they can be biological, chemical, or physical in nature (McSwane et al. 2003). Hazards that have little or no risk, or unlikely to occur, can often be monitored and controlled by standard operation procedures (SOPs; routine employee hygiene practices, cleaning procedures, etc.) and good manufacture practices (GMP) and need not necessary be critical control points addressed by the HACCP system (McSwane et al. 2003). The identification of hazards and the determination of the severity of the hazard are the initial steps in a hazard analysis. Hazards are risks associated with growing, harvesting, processing, distributing, repairing and/or using a raw material or food product. Hazard usually means the contamination, growth or survival of microorganisms related to food safety or spoilage. A hazard can also include dangerous chemical contaminants or foreign objects (glass or metal fragments). Risk is the estimate of how likely it is that the hazard will occur (Blaha 1999). Hazard analysis has been conducted for different products by different workers. Hazard analysis was conducted for the street venders in a resort town of Pakistan (Bryan et al. 1992), and Salmonella was found in many samples. Suwanrangsi et al. (1997) has done the hazard analysis of aquaculture products and the categorization of hazards associated with aquaculture products into physical, chemical and biological (Table 7.3). Anon (2004) has published the same flow chart reported to be revised from Tookwinas and Keerativiriyaporn (1996). It is almost clear that they are not keeping abreast of the emerging concept of PRP or not updating or amending their HACCP plan.

Table 7.3 Hazards associated with aquaculture products from Suwanrangsi et al.(1997).

CATEGORY	EXAMPLES OF HAZARDS
Biological hazards	Pathogenic bacteria- Salmonella, Shigella, E.coli, Vibrio cholerae, V.parahaemolyticus, V.vulnificus, Aeromonas hydrophila, Listeria monocytogenes etc. Parasites and Protozoa- Larva of parasites such as trematodes,cystodes, nematodes,(Clonorchis sinensis, Anisakis sp; Capillaria philippinensis etc.) Viruses- Hepatitis A, Norwalk virus etc. Mycotoxins - Aflatoxins
Chemical hazards	Veterinary residues- Hormones, growth regulators, antibiotics Pesticide residues- Herbicides, fungicides, insecticides etc. Heavy metals- Mercury, lead, cadmium, copper etc.
Physical hazards	Glass, wood, metal etc.

7.6.2.2 The determination of critical control points (CCP)

The determination of CCP is for the purpose of controlling the hazards. Several definitions are available for the CCP. According to Pierson and Corlett (1992), A CCP is "any point in the chain of food production from raw materials to finished product where the loss of control could result in unacceptable food safety risk". Blaha (1999) has stated that CCP is a location, practice, procedure or process which can be used to minimize or prevent unacceptable contamination, survival or growth of food-borne pathogens or spoilage organisms, or the introduction of unwanted chemicals or foreign objects. The significant hazards that might occur during processing need to be monitored and addressed as CCP (Sun and Ockerman 2005).

7.6.2.3 Establishment of monitoring procedures

Establishment and implementation of monitoring procedures are to determine that each CCP is under control. Monitoring should be undertaken by assigned staff, by using suitable methods for making observations, taking measurements, testing of samples and recording the results. Corrective action must be defined to be used when a CCP monitoring point shows that the system is out of control (Blaha 1999).

7.6.3 Critical Control Point Worksheet

Hazard analysis is a vital component of the HACCP system. It requires a good knowledge of aquaculture operations, access to technical literature and epidemiological data and a sound knowledge of the production environment achieved by observations and discussions with farmers (Suwanrangsi et al.1997). HACCP worksheet is a format showing all the steps in the production process along with significant hazards, control measures and a decision on CCPs. Many workers have pointed out that HACCP aims to ensure food safety with the minimum necessary control at a smaller number of CCPs (Taylor 2001,Vela and Fernandez 2003) and that the CCPs should be related to specific and significant safety issues (Taylor and Kane 2005).

Table 7.4 Hazard Analysis for Shrimp Aquaculture Production from (Suwanrangsi et al.1997).

Production step	Hazard	Severity	Risk	Significant Yes / no	Control at
SITE SELECTION	Chemical contamination Microbiological contamination	Medium /High	Low/ Medium	Yes	Prerequisite Control
GROWING • Pond condition • Water supply • Feed/Fertilize • Use of chemicals	Chemical Contamination Microbiological Contamination			Yes	Prerequisite Control by Good Farming Practices

and drugs	Salmonella Salmonella	High High	Medium Medium	Yes Yes	CCP CCP CCP
HARVESTING	Salmonella re-contamination Glass, Wood	High High	Medium Medium	Yes Yes	CCP CCP

A critical control point worksheet adopted from Suwanrangsi et al. (1997) is shown (Table 7.4). This worksheet projects the severity of the risk associated with various production steps and specifies whether pre requisite or HACCP control is needed. However, the present study disagrees with Suwanrangsi et al. (1997) on many points especially with respect to the determination of CCPs. Five CCPs are reported, of which two are agreeable because the antibiotics can be administered either as a bath or through incorporation in the feeds. This study suggests that the other three CCPs located at the water supply and harvesting steps are not true CCPs because the Salmonella contamination as well as the physical hazards like glass and wood can very well be controlled by good hygienic and good manufacturing practices. Taylor and Kane (2005) observed that clarification of the role of GHP in food safety will reduce the number of CCPs dramatically by identifying correctly the few real CCPs and lead to a sophisticated understanding of HACCP. An attempt is made hereby (Table 7.5) to study the various production steps, the management measures adopted during each step with a decision on CCPs. The HACCP format developed by Codex was used for the hazard analysis.

Table 7.5 Hazard Analysis Worksheet for shrimp farming

(1) Aquaculture step (from flow diagram)	(2) Identify potential hazards introduced controlled or enhanced at this step	(3) Are any Potential Food safety Hazards significant	(4) Justify your decision for column (3)	(5) What preventive measure(s) can be applied to prevent the significant Hazards	(6) Is this step a Critical Control Point (Yes/No)
Pond Preparation					
1.The pond bottom is ploughed, the sludge removed, dried and compacted	Biological Predators, competitors, benthic algae and disease	Yes	Could be present in the mud or carried with sludge from previous crop	Controlled by PRP	No

	carriers				
	Chemical	Yes	may contain organic load from previous crop	Sludge disposed away from the farm site	No
	Physical Black soil Turbidity	Yes	Could be present in the mud or carried with sludge from previous crop Ploughing may cause turbidity	Soil checked for black soil in wet condition.. Removed after ploughing and drying, controlled by compaction of pond bottom	No
2.Pond disinfected, Limed and filled with water	Biological bacteria	yes	Could be carried with the incoming water	Adherence to recommended treatment procedures and specifications	No
	Chemical PH	Yes	Quality and quantity of lime,disinfectant	Adherence to recommended treatment procedures and specifications	No
	Physical	No	None	None	No
Fertilization of pond water	Biological bacteria	yes	Could be carried with organic fertilizers like fresh Cowdung	Dried Cowdung or tested	No
	Chemical inorganic fertilizers	yes	Quality and quantity of inorganic fertilizer	Adherence to recommended treatment procedures and specifications	No
	Physical	No	None		No
Seeds are selected and transported to the farm site	Biological Virus, bacteria.	Yes	Could be carried with seeds	Receive disease free PCR tested seed from approved Hatcheries Controlled by HACCP	Yes
	Chemical	No	None	None	No
	Physical Stress. mortality	Yes	Longer transportation time	Transport seed in <6 hours	No
Seeds are transferred to plastic tanks. acclimatized.weak seeds eliminated and stocked	Biological	yes	Growing water,equipments	Controlled by PRP	No
	Chemical	yes	Growing water	Controlled by PRP	No
	Physical PH,salinity, D.Oxygen	yes	Growing water	Adherence to water quality specifications	No
cultured for about 75-120 days (during culture) 1)Water quality	Biological Virus,Bacteria	yes	Growing water	Controlled by PRP	No
	Chemical Heavy metals. pesticides	yes	Growing water	Controlled by PRP	No

	Physical PH,salinity, D.Oxygen	yes	Growing water	Controlled by PRP	No
2)Feed management	Biological	No	None	Proper feed management	No
	Chemical Antibiotics	yes	may be incorporated in feed	Purchase certified feed from approved suppliers	Yes
	Physical	No	None	None	No
Harvesting	Biological bacteria	yes	Temperature abuse. contact surfaces	Controlled by PRP	No
	Chemical	No	None	None	No
	Physical Filth	Yes	Pond bottom	Controlled by PRP	No
Sorting. Washing and Icing	Biological Bacteria	Yes	Temperature Abuse. contact surfaces. water and ice	Controlled by PRP	No
	Chemical	No	None		No
	Physical	No	None		No
Dip treatment with metabisulphite	Biological Bacteria	Yes	contact surfaces, Temperature abuse	Controlled by PRP	No
	Chemical Sulphites	Yes	Potential health problem	Adherence to recommended treatment procedures and specifications	No
	Physical	No	None	None	No
Storage and Transportation	Biological Bacteria	Yes	Temperature Abuse. contact surfaces	Controlled by PRP	No
	Chemical	No	None	None	No
	Physical	No	None	None	No

The safety hazard occurring step is regarded as the CCP and the non safety hazard occurring step as a CP and are included under the HACCP plan and PRP plan respectively. There are twos CCPs identified, the raw material receiving step and the feed. Hazards like Virus could be carried with the seed. The control measure suggested is source control, i.e, only certified virus free stock should be used for culture. The biological hazard (WSSV) identified at this step is regarded as a safety hazard and has been included under the HACCP plan. Stress and mortality are the physical hazards occurring at this step for which the preventive measures suggested are sticking to prescribed packing measures and limiting the transportation time to less than 6 hours. No significant chemical hazards are noticed at this stage. The Chemical hazards like antibiotics, even if present, may be negligible. Chemical hazards like antibiotics may be incorporated in feeds, which when present in the shrimp is a health hazard. The feed is therefore classified as a safety hazard and the preventive measures suggested are purchase of certified feed from approved suppliers. The feed should also be get tested in a recognized laboratory to assure its antibiotics free status. This step is a CCP and is also included under the HACCP plan. The physical and chemical hazards noticed at these steps as well as all the other hazards identified under other steps are either quality or hygiene related and hence assigned as non safety hazards and are included under the PRP plan.

Quality and quantity of disinfectant, lime, inorganic fertilizers, heavy metals, pesticides etc. in the growing water, metabisulphite in the dip treatment, etc. are the chemical hazards introduced and can be controlled by adherence to recommended treatment procedures and specifications. Temperature, PH, dissolved Oxygen, salinity and other water quality parameters, black soil, presence of filth and temperature abuse of harvested shrimp etc are the physical hazards identified and should be controlled by adherence to water quality specifications and recommended procedures. Organic fertilizers like fresh cowdung, growing water and soil, contact surfaces, water and ice etc are the sources of biological hazards. Quality checks are to be carried out as per specified norms at each step.

7.6.4 HACCP Plan Form

Table 7.6 is the HACCP planform showing details of the CCPs, the type of hazard, critical limits, the monitoring personnel, parameters, method and frequency, corrective actions taken, documentation and verification.

Table 7.6 The HACCP Planform for shrimp farming

Critical Control Point (CCP)	Significant Hazard(s)	Critical Limits for each Control Measure	Monitoring				Correct-ive Action	Record	Verifi-cation
			What	*How*	*Frequency*	*Who*			
Seed Feed	Virus Antibiotics	Seed and Feed tested for Virus/ antibiotics	Virus/ Antibiotics free certificatet From the suppliers	Check test certifi cates	Each arrival	Farm technician	Not accept Seed and feed	Records of virus/ antibiotics status for seed and feed	Check Of records

7.6.5 The Process Control Model

Several authors have opined that PRP can be used to work effectively with HACCP. According to Wallace and Williams (2001), a prime difficulty encountered in designing and implementing a HACCP programme can be in deciding what constitutes HACCP and what constitutes GMP/ GHP. Sperber (2005b) is of the opinion that HACCP cannot be effective when applied as an isolated system, it must be supported by PRP.

In the present study, based on the findings covered under 7.6.1 to 7.6.4 (from preparation of process flow chart through hazard analysis, determination of CPs and CCPs on the worksheet to HACCP planform), a model representing the process control operations in a shrimp farm has been developed and is illustrated in Fig. 7.6. This model represents the heart or the centre of activities of a shrimp farm. It shows the safety and quality issues arising upon hazard analysis in a shrimp farming operation, classified under CCPs and CPs and suggested to be controlled by HACCP and PRP respectively.

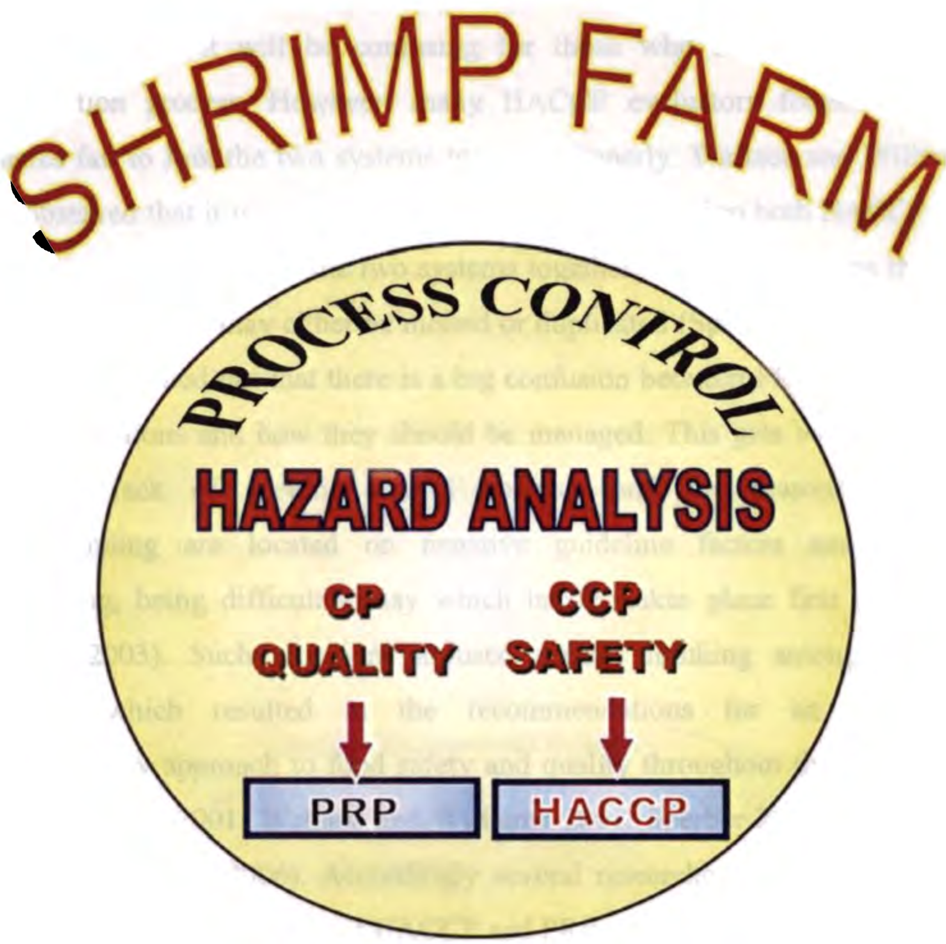

Fig.7.6: Safety and Quality management in Process control

7.7 Safety and Quality management Systems

The HACCP which was originally designed as a food safety management system, further expanded in practice to include the quality and hygiene parameters also. Such expansion of HACCP beyond its original concept, as believed by many HACCP practitioners, produced a system that is less effective as a food safety control mechanism (Sperber, 2005b). Several researchers have therefore emphasized that formal PRP are needed to support the implementation of HACCP (Mortimore and Wallace1998, Seward 2000, Mortimore 2001, Wallace and Williams 2001, Henroid and Sneed 2004). Consequently, many companies developed PRP plans also. Mortimore (2001) specified that it is important to be clear about what forms part of the HACCP system and what should be in place as a foundation or support system for HACCP, otherwise it will be confusing for those who are in the HACCP implementation process. However, many HACCP evaluators found that the companies fail to link the two systems together properly. Wallace and Williams (2001) observed that it is possible that a company may develop both HACCP and PRP systems, yet fail to link the two systems together. In such situations there is chance that the issues may either be missed or duplicated (Sperber 2005b). A few workers have pointed out that there is a big confusion between PRP and HACCP plan, their relations and how they should be managed. This gets worse because there is a lack of specific hazard analysis and the reasons for this misunderstanding are located on negative guideline factors and lack of understanding, being difficult to say which barrier takes place first (Vela and Fernandez 2003). Such situations aroused serious thinking among HACCP spokesmen which resulted in the recommendations for an integrated, multidisciplinary approach to food safety and quality throughout the entire food chain (Mortimore 2001, Wallace and Williams 2001, Sperber 2005b, Ababouch 2006, Bertolini et al. 2006). Accordingly several researchers designed different models by linking the concepts of HACCP and PRP.

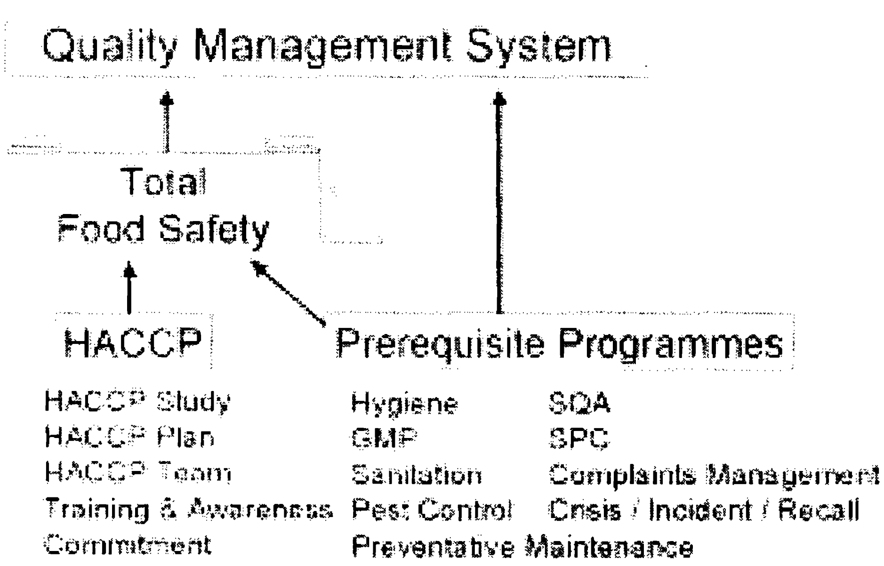

Fig.7.7 Food Safety within a Quality Management Program (from Mortimore 2001).

Mortimore and Wallace (1998) designed a model, which pictured the pre requisites as the HACCP support network showing the inter-relationship of management systems and procedures in food business for the production of safe, high quality products (Fig.7.1). Mortimore (2000) proposed a useful scheme to help differentiate between different types of CPs and CCPs and designed a model which addresses the safety hazards through the HACCP system and the quality and hygiene issues through the PRP (Fig.7.3). The relationships of PRP and HACCP combined together for a total food safety and quality management system were listed by Mortimore (2001) and is illustrated in (Fig. 7.7). Wallace and Williams (2001) has proposed a system to manage both HACCP and PRP within a quality management system such as ISO 9000 for facilitating the effective control of all issues and is illustrated in (Fig.7.8).

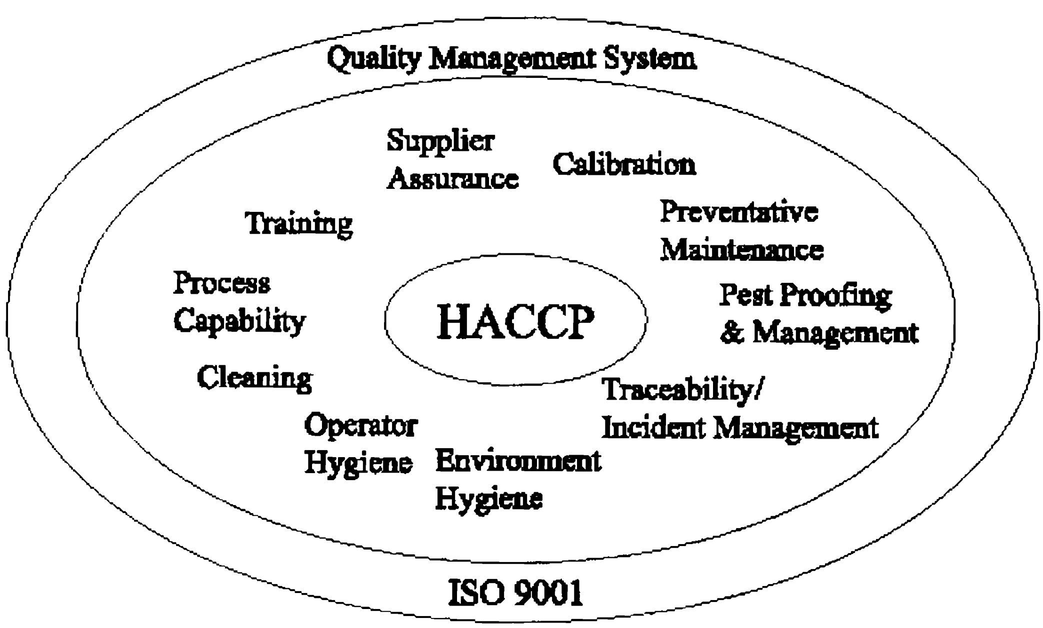

Fig 7.8. Safety and Quality management from (Wallace and Williams (2001)).

7.8 Development of a Safety and Quality management Model for Shrimp Farming Operations

Studies have indicated that there is a big confusion between PRP and HACCP plan, their relations and how they should be managed (Vela and Fernandez 2003). Similar observations have been made in the present study also while conducting the HACCP and PRP surveys discussed in Chapter (4). The concepts of HACCP and PRP were not clear to most of the respondents even when explained to them. There are reports pointing out the need for an integrated, multidisciplinary approach to food safety and quality throughout the entire food chain (Ababouch 2006). A few researchers have designed different models by linking the concepts of HACCP and PRP for managing both HACCP and PRP within a quality management system (Mortimore 2001, Wallace and Williams 2001).

In the present study, an attempt is made to bring the HACCP and PRP activities taking place in a shrimp farming operation under an umbrella, by co ordinating all the safety and quality control activities. A review of food safety literature and discussions with the shrimp farmers and others regarding hazard analysis urged the need for a model which could guide the farmers and the HACCP practitioners through the HACCP process. Shrimp farming operations includes many points where control is needed, but most of these are not critical. The findings discussed in the earlier paragraphs have already proved that if HACCP alone is applied, such quality and hygiene issues cannot be managed. It is in this context that the importance of implementing an integrated approach becomes significant. A model has been designed, by consolidating various concepts from similar models (Mortimore and Wallace1998, Mortimore 2000, Wallace and Williams 2001, Griffith 2000) which can be adopted as a generic model for safety and quality management in shrimp farming operations.

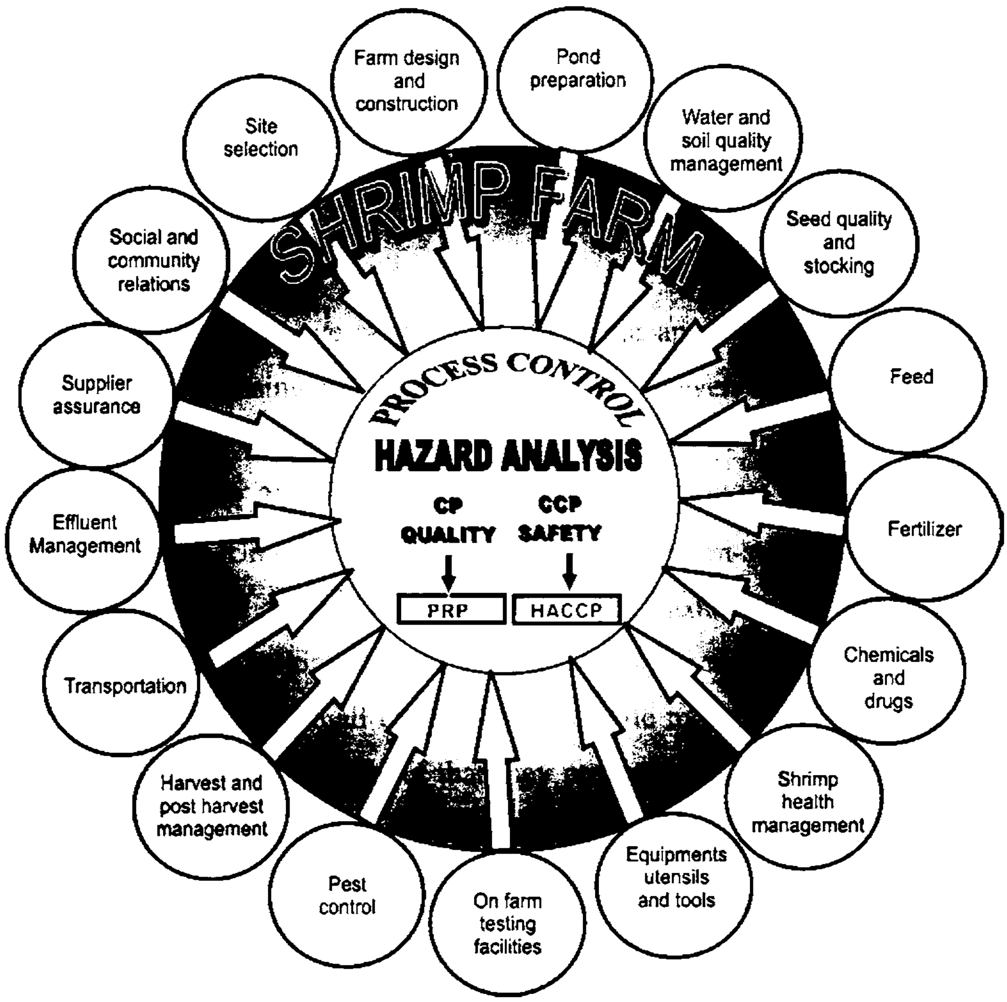

Fig.7.9: Safety and Quality management model for Shrimp farming

In the present study, the GMP/ GHP issues encountered in the shrimp farming process were identified and presented in Table 7.1. The major areas where these quality and hygiene issues could arise were identified and grouped under PRP as a support plan or foundation for HACCP system and is illustrated in Fig.7.2. The process flow chart (Table 7.2) and the hazard analysis worksheet prepared (Table 7.5) identified the CPs and CCPs and designed a model which addresses the safety hazards through the HACCP system and the quality and hygiene issues through the PRP and is illustrated in Fig.7.6. The combination of the two figures (Fig.7.2 and Fig.7.6) resulted in the birth of a 'Supermodel' the safety and quality management model, the HACCP and PRP combination model (Fig.7.9) which, the shrimp farmers all over the country will like to adopt, the HACCP practitioners of our country feel proud of and will raise the position of our country in the HACCP ranking.

7.9 Discussion

Studies have pointed out that most applications of HACCP in foodservice areas are using only five criteria instead of seven criteria (Bryan 1990, Walker and Jones 2002) and the five-stage HACCP needs to change to full seven-stage HACCP (Kang 2000). However, Walker et al. (2003) reported that the proposed European Union legal requirement of full seven-stage HACCP in all business probably will cause problems for small and medium sized multi-product businesses which are lacking in-house knowledge and access to experts. Taylor (2001) has indicated that small companies have little motivation for adoption of HACCP, largely due to their belief that they produce safe food already and the only pressure to apply HACCP for these companies have been from legislation. Sun and Ockerman (2005) observed that the application of HACCP in foodservice areas still poses to really set up the HACCP system and put it to work and it is easier to implement HACCP in large foodservices operations compared to small food businesses. Panisello and Quantick (2001) reported that reasons for not implementing HACCP system seem far more complicated than ever imagined and it cannot be solely explained purely in terms of unwillingness by manufacturers but rather by the presence of several technical barriers that may impede the benefits of the application of the HACCP system.

7.10 Conclusion

In the present study, during the hazard analysis, CCPs were identified at two steps, the seed and feed. The need for seed certification has been suggested under chapter 4 also. If the seed and feed used in shrimp farming are certified, safety of the ingredients used can be assured. Even if certified seed and feed are used, the safety will be affected if they are not properly stored and used without getting contaminated and mixed up which has been discussed under the PRP. That is why this study recommends a combined approach of HACCP and PRP. The model developed in the present study is sufficient to explain the relationship between PRP and HACCP and the need for co-existence of PRP and HACCP in shrimp farming operations. The results obtained in the HACCP and PRP surveys conducted and discussed in Chapter 4 indicated that proper shrimp farming practices were followed in most of the farms studied in Kerala. Hence the present study recommends the implementation of five stage HACCP in shrimp farming i.e, PRP with appropriate source control for the CCPs identified. However, the implementation of HACCP will require people with HACCP knowledge and management skill to really set up the system and put it to work. Hence qualified and approved 'Farm Technicians' will be required. Being small scale in nature and have little motivation for adoption of HACCP, the source to apply HACCP for the farms will be either from legislation or pressure from the importing countries or buyers.

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Chapter-8

DEVELOPMENT OF SAFETY AND QUALITY MANAGEMENT SYSTEM MODEL FOR SHRIMP HATCHERY

8.1 Introduction

HACCP was established 30 years ago, and has become the universally accepted method for increasing food safety and have been adopted for food assurance in many food areas (Griffith 2000). Several researches had concluded that improper food handling and storage techniques need to be improved and changed, in order to decrease foods that caused illnesses (Manask 2002, Walker and Jones 2002, Henroid and Sneed 2004, Bas et al. 2006). This can be accomplished by education and applications of HACCP which has proved to be the best methods to achieve this goal (Sun and Ockerman 2005). Horchner et al. (2006) suggested the risk profiling approach to conduct the hazard analysis using risk assessment. The recently proposed generic frameworks for managing foodborne risks to human health by the CAC (CAC 2002) requires consideration of risk management of hazards prior to slaughter based on application of HACCP principles. According to Panisello and Quantick (2001), the success in implementing and maintaining a HACCP programme depends on how its four basic pillars commitment, education and training, availability of resources and external pressure are prioritized and organized in a company. Taylor (2001) suggested that the highly motivated nature of the small companies must be channeled into the application of HACCP principles in order to secure safety across the entire food chain and can only be achieved if the food industry, researchers, educators, enforcement agencies and governments pool resources and work towards a common goal. Several researchers have pointed out that the food safety must be ensured with minimum necessary control, with a small number of CCPs and with the necessary record keeping which can be integrated into the existing practice (Taylor 2001, Taylor and Kane 2005). Constant turnover of employees is a barrier to the proper implementation of the HACCP system, as employees need time and training in order to fully comprehend and use the system (Panisello and Quantick 2001). An understanding of HACCP and the related PRP , as well as a commitment from management, must be established to make HACCP successful (King 1992).

Sun and Ockerman (2005) observed that the application of HACCP in foodservice areas still poses needs for people with HACCP knowledge and management skill to really set up the HACCP system and put it to work. An advantage of HACCP is to focus resources on the most important control points, which can minimize resources used to improve safety (Unnevehr 2000). Several researchers have pointed out the importance of HACCP as a regulatory and a cost effective process control tool (Motarjemi and Koaferstein 1999, Unnevehr and Jensen 1999). The need for training of personnel in the industry for the effective implementation of HACCP has been pointed out (CAC 1997, NACMCF 1998). The implementation process involves a sequence of twelve steps in which the seven basic principles of HACCP are included. Studies have pointed out that most applications of HACCP in foodservice areas are using only five criteria instead of seven criteria (Bryan 1990, Walker and Jones 2002) and the five-stage HACCP needs to change to full seven-stageOP HACCP (King 1992).

However, Walker et al. (2003) reported that the proposed European Union legal requirement of full seven-stage HACCP in all business probably will cause problems for small and medium sized multi-product businesses which are lacking in-house knowledge and access to experts. HACCP approach requires food products to be prepared or processed in certified plants and establishments which requires that the plant meets minimal requirements in terms of layout, design and construction, hygiene and sanitation and suggests that the verification of PRP can be carried out concurrently with the HACCP assessment in order to have an overall assessment of safety and quality management especially for processors who use the HACCP approach to address GMP/GHP implementation as well (Ababouch 2000). Several researches had concluded that studies about HACCP in foodservice areas are important because it can support the future development of hygiene legislation to provide safe foods from farm to fork (Soriano et al. 2002, Walker and Jones 2002). According to Horchner et al. (2006) the designers of on-farm food safety programs may not warrant full HACCP plans at the individual enterprise level as long as appropriate GAP is in place. A few studies have pointed out the importance of an integrated, multidisciplinary approach to food safety and quality throughout the entire food chain (Ababouch 2000, Sperber 2005b, Bertolini et al. 2006).

Processing flow charts incorporating the possible CCPs and SOPs were developed (Griffith 2000). A model for shrimp hatchery operations by linking the concepts of HACCP and PRP has been developed by Sebastian and Ramachandran (2007). Schwarz (2007) has developed an operating flow diagram for shrimp hatchery operations along with possible CCPs and SOPs. In the present study, the previous surveys conducted in the hatcheries, as discussed in Chapter (6), also pointed out the need for an implementation model which could help the hatchery operators in applying the concepts of HACCP and PRP in their day today activities, explain these concepts in an easily understandable way and ensure improvements in quality and safety of the PL raised. This chapter therefore is an attempt to identify the various steps and the factors involved in the hatchery production of *P.monodon* postlarvae, differentiate the CPs and CCPs, segregate the HACCP and PRP aspects to unite and arrange them on a quality and safety management wheel for the overall quality and safety management of the shrimp hatchery operations.

8.2 Methodology

As discussed in Chapter 3.2

8.2.1 PRP Assessment of Hatchery Layout and Facilities

The same shrimp hatcheries and hatchery operators selected for the HACCP principles adherence and PRP study were selected for the PRP evaluation studies. As part of the PRP assessment, details regarding hatchery layout, seawater filtering and storage facilities, laboratory facilities etc. were collected and an assessment of the facilities including equipments, structure of premises, waste disposal, cleaning and disinfection, personal hygiene and pest control etc. was done.

8.3 Results and Discussion

8.3.1 The Pre Requisite Programs In Shrimp Hatcheries

The PRP provide the basic environmental and operating conditions that are necessary for the production of safe, wholesome food. Hatcheries simulate the natural conditions under which the shrimp normally complete the larval development. GMPs followed by the hatcheries maximize larval survival and growth and produce healthy PL ready for stocking into nursery or grow out ponds (AAI 2002). The concepts of PRP and how it will support the HACCP implementation etc. had been reported by several researchers and a good account of this has been detailed in Chapter 7 (3.1). The operating flow diagram for hatchery operations prepared by Schwarz (2007) indicated the need for standard operating procedures (SOPs) for the control of human and animal disease vectors as well as for facility/equipment disinfection and is illustrated in Fig.8.2. The control of human disease vectors included limiting personnel access, appropriate entry and exit disinfection, employee training and record keeping, and maintenance of facility access and disinfection records. The SOPs for control of animal disease vectors suggested include fencing, animal excluder devices, employee training programs, maintenance of fencing and animal excluder inspections. Disinfection of facilities and equipment are hatchery SOPs because facilities and equipment may transfer LSPs. These SOPs include tank and equipment disinfection, and maintenance of employee training records and disinfection records.

In the present study, the quality and hygiene issues which may arise from the processing and the surrounding hatchery environment were separated to be addressed through the PRP. The PRP identified for a shrimp hatchery included the following: site selection, hatchery design and premises, water, algal culture, artemia nauplii production, encapsulated feed, utensils and packagings, supplier assurance, employee hygiene and habits, cleaning, sanitation and shut down, chemicals and drugs, inhouse testing and quality standards, transportation, pest control, effluent management and training.The PRP were identified based on the guidelines of Joshua et al.(1996), AAI (2002), Ravichandran and Pillai (2004), GESAMP (2005) and Subasinghe (2005).

8.3.1.1 Site selection

Penaeid shrimps are marine in origin and the early larval forms are purely marine and need the marine environment for growth and survival. Hence, the hatchery technology should provide the larvae with the most conducive environment similar to that of the sea (Ravichandran and Pillai 2004). The hatcheries draw their water from the sea and so the quality of seawater available is a very important criterion for site selection. The water available in the area should be free from agricultural and industrial pollution (AAI 2002).

The major criteria for site selection has been reported (Joshua et al. 1996, AAI 2002) and the water quality parameters for an ideal site (Ravichandran and Pillai 2004) is shown in Table 8.1.

Table 8.1 Water quality requirements at a hatchery site

Parameters	Tolerable limits	Optimal levels
Temperature (^{o}C)	18-36	28-32
Salinity (ppt)	26-34	30-34

P^H	7.0-9.0	8.0-8.4
Dissolved Oxygen (ppm)	Above 3	Above 4
Ammonia-N (ppm)	Upto 0.1	Less than 0.01
Nitrite-N (ppm)	Upto 0.1	Less than 0.01

8.3.1.2 Hatchery design and premises

A basic prerequisite in the design and construction of a hatchery is an understanding of the biological requirements of the species. Ravichandran and Pillai (2004) reported that a hatchery should have provisions for broodstock maintenance, induced maturation, spawning/hatching, larval rearing, live feed culture and postlarval rearing as well as infrastructural facilities like seawater supply system, air supply system, tanks and buildings. The layout of the hatchery facility should be in such a manner as to facilitate easy flow and access for cleaning and inspection. The rearing tanks should be of such a nature that it can be easily cleaned and disinfected and should be free of structural damage that can lead to bacterial hide outs and consequent contamination. The hatchery premises should be kept clean and free of dust. The employee rest rooms shall be maintained but isolated from the larval rearing area and maintained in clean condition (AAI 2002).

8.3.1.3 Water

Hatcheries draw water from the sea. The water supply system normally includes settling tanks to remove larger particles and a battery of filters for water treatment and disinfection. Water should be filtered to exclude protozoans and other naturally occurring undesirable organisms that can compete with shrimp larvae for space and food and which also bring in diseases (AAI 2002). Ravichandran and Pillai (2004) have prepared a flow diagram for water treatment in shrimp hatcheries Chlorine is the commonly used disinfectant. The usual dosage of chlorine ranges 5-20 ppm available chlorine and the excess chlorine should be neutralized by adding sodium thiosulphate (Ravichandran and Pillai 2004). EDTA which is used as a chelating agent helps in reducing the concentration of heavy metals as well as bacterial contamination of shrimp eggs. There shall be separate pumps, tanks etc. for freshwater intake (AAI 2002).

8.3.1.4 Algal Culture

Joshua et al. (1996) have discussed the environmental conditions, (light, temperature and aeration) the facilities, (culture room, culture vessels, seawater) the operating procedures, the hygienic precautions (pure strains of algae should be used for mass culture, all the items in the algal section like air hoses, glasswares, airstones, FRP tanks etc. should be disinfected before use and UV sterilized seawater should be used for algal culture) and documentation etc. required for operation and management of the algal section.

8.3.1.5 Artemia Nauplii Production

The conditions and facilities required for efficient hatching of artemia cysts, the harvesting methods of artemia nauplii etc. have been discussed (Joshua et al.1996). Vaseeharan and Ramasamy (2003) indicated that *Artemia* nauplii are one of the principal agents for transmission of pathogenic *Vibrio*spp. infections in post larval *P. monodon.* The hygienic precautions to be taken are the following; The cyst should be treated with bleaching solution to avoid bacterial contamination and to soften the cyst for easy hatching and then washed. Unhatched cysts and cyst shells should be discarded. Healthy nauplii only should be harvested and enriched using HUFA and PUFA. The harvested nauplii should be transferred to disinfected seawater before feeding to PLs (MPEDA 2002).

8.3.1.6 Encapsulated feed

The present study identified encapsulated feeds as a CCP, due to the possibility that it may contain antibiotics incorporated. Therefore it is recommended that the feeds should be tested before or after purchasing. The feed sizes and feeding schedule have been discussed (Joshua et al.1996).

8.3.1.7 Utensils and packagings

The contact surfaces of every kind including tables, utensils, outer garments of workers etc. should be regularly cleaned and sanitized. The utensils should be cleaned and sanitized before and after every use. There should be a written cleaning schedule for the plant and strictly adhered to. The packaging materials should be kept covered to prevent any contamination (Joshua et al.1996).

8.3.1.8 Supplier assurance

The feed, chemicals, spawners, other aids and accessories etc. should be received from registered suppliers.

8.3.1.9 Employee hygiene and habits

The movement of people, equipments and other things from one section to the other should be restricted. The employees should follow good hygienic practices, proper washing facilities and hand and foot dips should be provided at the entrance to each section (Joshua et al.1996). Schwarz (2007) has also pointed out the need for following appropriate entry and exit disinfection by the employees.

8.3.1.10 Cleaning, sanitation and shut down

The utensils should be cleaned and disinfected before and after each use and the culture tanks, walls and floor of the building, , the PVC lines, water supply lines and reservoir tanks etc. at frequent intervals. The facility should be shut down at least annually for maintenance work. Proper cleaning and drying of every part of the hatchery is essential to ensure better production in the next cycle (Joshua et al.1996). Schwarz (2007) also suggested the need for appropriate SOPs for disinfection of facilities and equipments. These SOPs include tank and equipment disinfection, maintenance of employee training records and disinfection records. It has been recommended to use 100 ppm sodium hypochlorite for 10 minutes to chlorinate and dry the hatchery and live feeds production tanks between production runs and to sterilize all equipment in 100 ppm sodium hypochlorite dips for 10 minutes.

8.3.1.11 Chemicals and Drugs

Antibiotics or other pharmacologically active substances that are banned should not be used. However probiotics useful in controlling diseases like Vibriosis can be used. All chemicals should be properly labelled and stored (MPEDA 2002). Schwarz (2007) has recommended to maintain and test the chemical concentrations.

8.3.1.12 Inhouse Testing and Quality standards

The PL20s should be screened for WSV and subjected to salinity drop test and exposure to 100ppm formalin before sales. Check the PL for activity, pigmentation, survival rate, body length, muscle to gut ratio, microbial infection etc. PLs below 15 as well as infected ones should not be sold (MPEDA 2002).

8.3.1.13 Transportation

Standard 15-20 litre double layered polythene bags should be used for packing PL. Always the packing water temperature should be kept 50c less than the normal water temperature and the bag filled with oxygen and water at the ratio 2:1. The bags should be placed in cardboard boxes lined with thermocol sheets with a bag of ice inside to maintain the temperature (MPEDA 2002).

8.3.1.14 Pest control

The pests include rodents, birds and insects. These pests are dangerous in that they could be carriers or vectors of several micro organisms. The design of the hatchery is important in limiting the attractiveness to pests and providing barriers to their entry. Effective pest control programmes play a key role in hatchery sanitation as many of the hatcheries have outdoor culture practices. Similar suggestions have been made by other workers also. The studies conducted by Schwarz (2007) suggested the need for appropriate SOPs for control of animal disease vectors which include fencing, animal excluder devices, employee training programs, maintenance of fencing and animal excluder inspections.

8.3.1.15 Effluent management

Islam et al. (2004) in a survey of 36 shrimp hatcheries in the Western Hemisphere, reported daily discharge quantities of 50–2000 m3 from hatcheries with shrimp PL production ranging 10–100 million PL/month, depending on the size of the hatchery. Most hatcheries in their report did not have facilities for monitoring chemical composition of their discharges. The Indian Association of Shrimp Hatcheries reported a high degree of effluent loadings in shrimp hatcheries (Islam et al. 2004). Infected larvae and fry should be isolated and disinfected before releasing into open waters in order to prevent spreading of disease and environmental degradation. The effluents from the hatcheries should be treated before discharging into the open waters (AAI 2002).

8.3.1.16 Training

Several researchers have pointed out that the success of a HACCP programme depends on the education and training of employees on the importance of their role in maintaining food safety. The operating flow diagram for hatchery operations prepared by Schwarz (2007) also indicated the need for SOPs for employee training and record keeping. The employees need training in GMP,GHP and good laboratory practices (GLP).

8.4 Development Of Prerequisite Programs For A Shrimp Hatchery

The present study identified the above mentioned practices (8.3.1.1 to 8.3.1.16) as PRP for the shrimp hatchery operations and is represented in Fig.8.1. Several researches had concluded that before developing an HACCP plan for a production procedure, the establishment of PRP is indispensable

(NACMCF 1997, Blaha 1999, Vela and Fernandez 2003, Henroid and Sneed 2004, Bas et al. 2006).

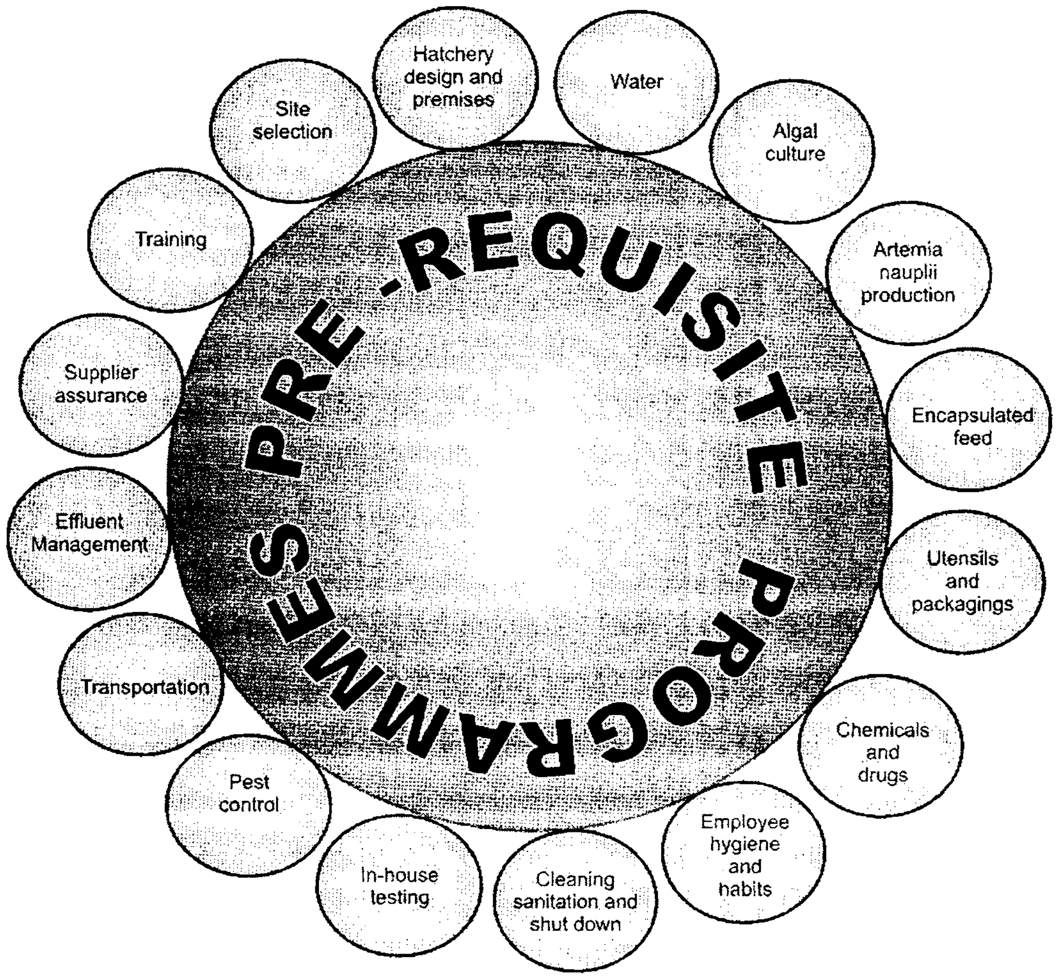

Fig.8.1: The Pre Requisite Programmes in a Shrimp hatchery

Similar studies have been conducted by Schwarz (2007), who prepared an operating flow diagram showing the CCPs and SOPs. SOPs are written practices and procedures designed to enhance production and product quality and safety (Schwarz 2007). The studies by Schwarz (2007) in fact include the GHP only. The SOPs for the GMP and GLP were not mentioned. The practices mentioned under 8.3.1.1 to 8.3.1.16 in the present study include the GHP, GMP and GLP and hence called the PRPs. The SOPs mentioned by Schwarz (2007) can only be called as a 'pre requisite hygienic program' whereas the PRP developed in the present study (Fig.8.1) can be considered as the 'pre requisite programs' as it includes the GMP, GHP and GLP issues. The differentiation of quality and hygiene issues carried out (Table 8.2) further clarifies this.

8.5 Differentiation of Quality and Hygiene Issues in a shrimp Hatchery

The PRP are regarded as the cornerstones of product safety and quality. The PRP in a shrimp hatchery operation, cover all those activities which interact within and across various processes, and may influence the final safety outcome of the PL. ThePRP are comprised of GMP, GHP and GLP. The present study attempted to differentiate the hatchery practices identified through 8.3.1.1 to 8.3.1.16 and illustrated in Fig.8.1 as PRP, into GMPS, GHPs and GLPs. Though disagreement might arise on whether GMP or GHP, this attempt only aims to clarify that these are CPs only and not CCPs. Once the analysis of the quality and hygiene issues that may arise from the surrounding environment are addressed through the PRP, the firm can focus on the hazard analysis of the product and process selected. The differentiation of quality and hygiene issues related with the PRP are shown in Table 8.2. Several researchers have opined that an HACCP system can be effective only if it is based on sound GMP/GHP. Several studies have concluded that the inability to differetiate between CPs and CCPs often results in inclusion of many CPs along with CCPs thereby increasing the number of CCPs which reduces the effectiveness of HACCP. The views expressed by different authors regarding quality and hygiene issues have been discussed in Chapter 7.5.

Table 8.2:Differentiation of Quality and hygiene issues

Site selection	GMP (Good manufacturing practices)
Building and premises	GMP (Good manufacturing practices)
Live feed	GMP (Good manufacturing practices)
Encapsulated feed	GMP (Good manufacturing practices)
Water	GMP (Good manufacturing practices)
Utensils and packaging	GMP (Good manufacturing practices)

Transportation	GMP (Good manufacturing practices)
Supplier assurance/guarantee	GMP (Good manufacturing practices)
Chemicals and drugs	GMP (Good manufacturing practices)
Employee hygiene and habits	GHP (Good hygienic practices)
Cleaning sanitation and shut down	GHP (Good hygienic practices)
Inhouse testing and laboratory	GLP (Good laboratory practices)
Effluent management	GMP (Good manufacturing practices)
Pest control	GMP (Good manufacturing practices)

8.6 The Process Control

Several studies have pointed out that preparation of flow charts and recording on worksheets are the basic procedures to be considered before implementation of HACCP and a good account of this has already been covered under Chapter 7.6.

8.6.1 Process flow chart

All the specific steps involved in the production process, from the broodstock are received until the PL leaves the hatchery are shown in the flow chart (table 8.3). The sequence of operations or the flow of products through the facility for the production of PL is divided into eight steps. Quality checks are to be carried out as per specified norms at each step. Selection of broodstock is identified as a CCP. The condition and size of the broodstock at receiving should be as per guidelines. The Guidelines on GMP (AAI 2002) in respect of broodstock selection and maturation requires that the spawners should be free from viral diseases in order to avoid vertical transmission of the diseases. Strains which show symptoms of stress, red pigmentation, lesions on exoskeleton, damage to gills etc. should be avoided. Transportation of the brooders in disinfected seawater supplied by the hatcheries and gradual acclimatization will help in avoiding bacterial contamination especially attack of Vibrio and reduces mortality. The broodstock should be screened for WSV and MBV and infected ones should not be used for maturation. The selected stock should be given appropriate feeds and subjected to formalin treatment before leaving for spawning. Individual and repeated spawning should be encouraged. The broodstock is then segregated, females subjected to induced maturation and transferred into maturation tanks. The first three steps in the flow diagram are not at all in practice in Kerala owing to the non availability of broodstock. The hatchery rearing either starts from the collection of gravid spawners from the sea or the acclimatization of nauplii brought from neighbouring states, most often from the nauplii stocking onwards. The eggs should be collected immediately after spawning and washed well in good quality water followed by washing with formalin and washed again with water. After hatching, the nauplii should be thoroughly washed in disinfected water and screened for WSV before stocking (AAI 2002). The larvae (PL 3) are collected and transferred into post larval rearing tanks as the next step and reared to PL18-PL22. The larvae should be reared in pathogen free seawater under optimum conditions of temperature, oxygen and salinity and fed properly with microalgae, artemia nauplii as well as micro encapsulated feeds. Separate utensils should be used for each tank and traceability should be maintained. Strict hygienic and sanitary practices should be followed. The PL3s should be screened for WSV before transferring to PL tanks. The guidelines on post larval rearing recommends that the larvae should be reared in pathogen free seawater under optimum conditions of temperature, oxygen and salinity and fed properly with artemia nauplii as well as micro encapsulated feeds. The waste materials should be siphoned out before next feeding. Separate utensils should be used for each tank and traceability should be maintained. Strict hygienic and sanitary practices should be followed. Heaters should not be used to increase temperature beyond 30^0c.

Table 8.3. Flow Chart for the production of Postlarvae

Step 1	Broodstock collected and transported to the hatchery
Step 2	Broodstock acclimatized,disinfected and transferred into maturation tanks
Step 3	Broodstock segregated, females subjected to induced maturation and transferred into maturation tanks

Step 4	Gravid spawners acclimatized, disinfected and transferred into spawning tanks
Step 5	Eggs are harvested, washed and transferred into hatching tanks
Step 6	Nauplii are harvested, acclimatised and transferred into larval rearing tanks
Step 7	Larvae are collected and transferred into post larval rearing tanks and reared to PL18-PL22
Step 8	Post larvae are PCR tested and marketed

Similar flow diagrams for shrimp hatchery operations has been prepared by Schwarz (2007) and is illustrated in Fig.8.2. In this flow chart, there are three CCPs. According to Schwarz (2007), the hatchery-related CCPs include brood stock acquisition, influent water, brood stock feeds and live feeds. But, the present study has identified only two CCPs, the brood stock acquisition and brood stock feeds. The influent water is considered as a PRP in the present study. The influent water is subjected to a series of treatments as mentioned under 8.3.1.3 and the water is sent to the processing section only after ensuring the stipulated quality norms. Studies have pointed out that the presence of PRP can significantly reduce the number of CCPs. The present study proves this finding and suggests that the influent water shown as CCP in the flow diagram for shrimp hatchery operations prepared by Schwarz (2007) could also be grouped along with other SOPs, if proper water treatment methods were adopted in the hatchery. According to Schwarz (2007), influent water for the hatchery is considered a CCP because this water may contain LSPs. Again, the recommended procedures if LSPs are detected also have been mentioned which includes disinfection of incoming water with 100 ppm sodium hypochlorite for 10 minutes followed by UV (90,000 uw/cm2 for 60 minutes) or ozone (0.5 ug/ml for 10 minutes) treatments with monitoring of chlorine levels, UV bulb, ozone concentration, and contact times. These treatments are sufficient to destroy the suspected pathogens and moreover, the hatchery water is under the hatchery operator's control and so this study indicates that the inclusion of influent water under CCPs as grouped by Schwarz (2007) is not justifiable.

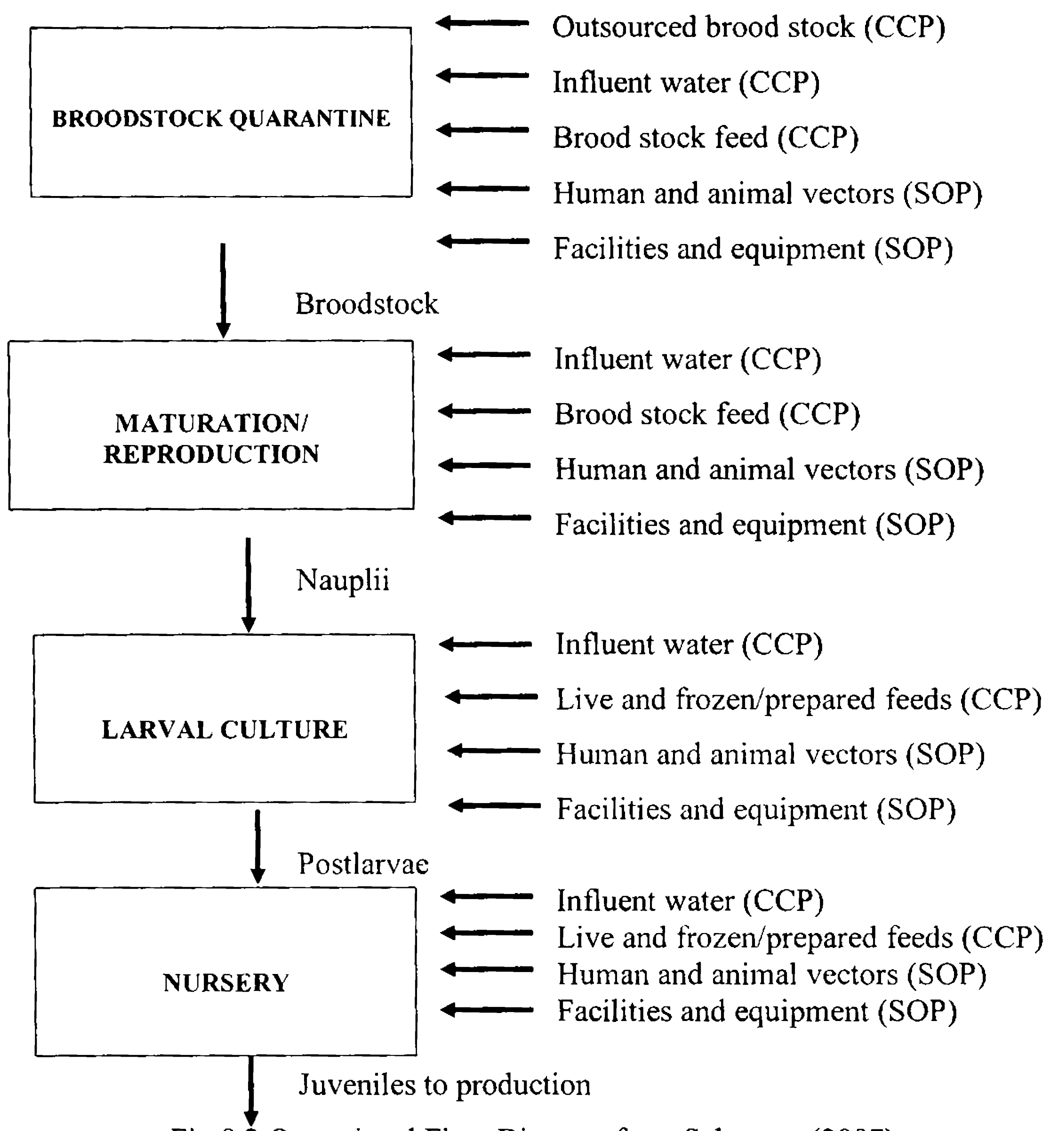

Fig.8.2 Operational Flow Diagram from Schwarz (2007).

8.6.2 Hazard Analysis

There are seven standard principles of the HACCP system recommended by the FDA Food Code (McSwane et al. 2003). They are (1) hazard analysis, (2) identify the critical control points (CCPs), (3) establish critical control limits, (4) establish procedures to monitor CCPs, (5) establish the corrective action to be taken when monitoring indicates that a critical limit has been exceeded, (6) establish procedures to verify that the HACCP system is working, and (7) establish effective record keeping that will document the HACCP system. Of these, the first step, Hazard analysis requires that both the likelihood of occurrence and the severity of that hazard should be considered, in effect, an assessment of risk (Fig.8.3). A successful HACCP team must have a clear understanding of the significance of the identified hazards because the hazards identified requires specific control measures as opposed to being managed through PRP (Mortimore 2001).

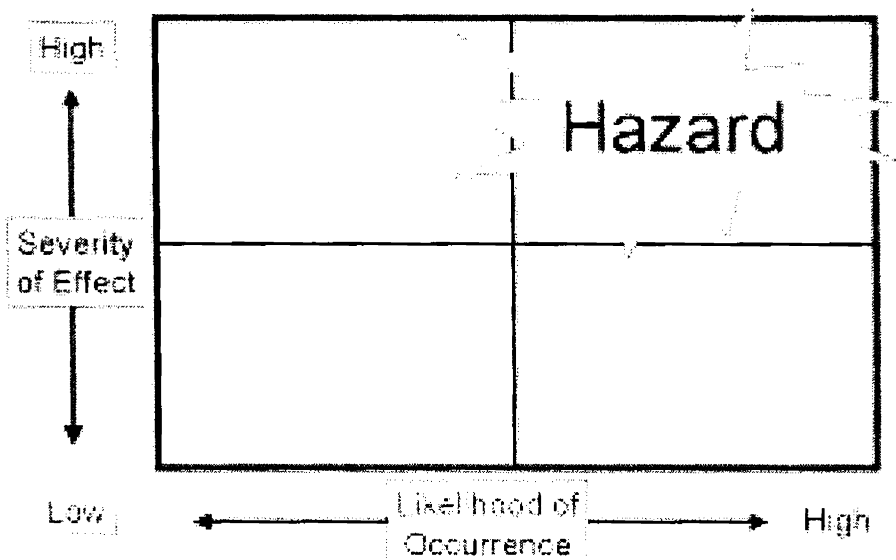

Fig.8.3 Hazard Analysis from Mortimore (2001).

Several workers have discussed the identification, (Codex 1997, Griffith 2000) monitoring, (Blaha 1999, McSwane et al. 2003) analysis of hazards, (Bryan et al. 1992, Suwanrangsi et al. 1997) determination of CCPs, establishment and implementation of monitoring procedures (Pierson and Corlett 1992, Blaha 1999, Sun and Ockerman 2005) etc. which has been discussed in detail in Chapter 7.6.2.1.

8.6.3 Critical Control Point Worksheet

Table 8.4. Hatchery Production of Shrimp Seed

Differentiation of CPs and CCPs Hazard Analysis Worksheet

Processing step	Identify potential hazards introduced controlled or enhanced at this step	Are any Potential Food safety Hazards significant	Justify your decision for column (3)	What preventive measure(s) can be applied to prevent significant Hazards	Is this step a Critical Control point
Broodstock collected and transported to the hatchery	Biological Virus,bacteria, parasites	Yes	could be carried with broodstock	broodstock tested for Virus. Others controlled at subsequent step	Yes CCP
	Chemical	No	None	None	No
	Physical Stress, mortality	yes	Longer transportation time	Transport broodstock in <8h	No
Broodstock acclimatized,disinfected and transferred into maturation tanks	Biological bacteria, parasites	Yes	could be carried with broodstock	Adherence to recommended treatment procedures and specifications	No
	Chemical antibiotics	yes	prophylactic dip treatment	Adherence to recommended treatment procedures and specifications	No
	Physical salinity, temperature	yes	Hatchery water	Controlled by adherence to water quality specifications	No
Broodstock segregated, females subjected to induced maturation and transferred into maturation tanks	Biological	No	None	Controlled at previous step	No
	Chemical	No	None	None	No
	Physical	yes	Hatchery water	Controlled by PRP	No
• Gravid spawners acclimatized,	Biological	yes	Water, contact surfaces	Controlled by	No

disinfected and transferred into spawning tanks	bacteria			PRP	
	Chemical antibiotics	yes	prophylactic dip treatment	Controlled at subsequent step	No
	Physical	No	None	None	No
Eggs are harvested, washed and transferred into hatching tanks	Biological virus	yes	could be carried from broodstock	broodstock not received if WSV positive	No
	Chemical	No	None	None	No
	Physical	No	None	None	No
Nauplii are harvested, acclimatised and transferred into larval rearing tanks	Biological virus	Yes	could be transferred to the egg	broodstock not received if WSV positive	No
	Chemical	No	None	None	No
	Physical salinity, temperature,D.O	yes	Rearing water,	Controlled by PRP	No
Larvae are collected and transferred into post larval rearing tanks and reared upto PL18-PL22	Biological Virus,bacteria,	Yes	Could be present in the nauplii Rearing water,equipments	Controlled by PRP	No
	Chemical	yes	Antibiotics could be present in the feed	Feed tested for antibiotics	No
	Physical	yes	Rearing water	Controlled by PRP	
Post larvae are PCR tested and marketed	Biological virus	Yes	May be transferred with post larvae	Controlled at previous step.still verified for here.	No
	Chemical	No	None	None	No
	Physical Health condition	yes	Diseased, undernourished	Controlled by PRP	No

- This step is a CCP if the Gravid spawners collected from the sea are used for spawning as the spawners could be virus carriers.

Recording on worksheets are one of the basic procedures that need to be considered before implementation of HACCP in foodservice (Bryan 1981). Mortimore (2001) has reported that though HACCP is a tool for product safety management, in practice, it links with many other management systems and it is unlikely that a HACCP system could be effectively implemented in the absence of some of these other management systems, for example, hygiene, whether it is a large or small organization. Such information and understanding of the relationship of HACCP with other systems is likely to lead to a more structured and systematic approach. It will also aid understanding of where additional CPs can be effectively set up. This simple relationship between CPs and CCPs must be understood if HACCP is to be used to best effect (Mortimore 2001). In the present study, the preparation of this work sheet (Table 8.4) takes into account the importance of other such management systems like hygiene and hence the study identified a large number of CPs, compared to the CCPs. The information required for the preparation of this worksheet was gathered from observations and studies on the various hatchery activities, discussions with hatchery personnel and a review of technical literature and epidemiological data. In the present study, the hazards that are expected to occur at each step in the process flow chart are listed out and are categorized into physical, chemical and biological hazards. Those hazards which are of such a nature that their elimination or reduction to acceptable level, if not properly controlled may result in an unsafe, unwholesome product is designated as a safety hazard. Hazards other than safety hazards such as manufacturing practices or hygienic practices related hazards are designated as non safety hazards. The points of occurrence of safety hazards are regarded as CCPs and the points of occurrence of non safety hazards are regarded as CPs. The safety hazards are addressed in the HACCP plan and the non safety hazards are addressed in the PRP plan.

This worksheet (Table 8.4) presents all the steps in the production process along with significant hazards, control measures and a decision on CCPs. By all means it can be adopted as a generic HACCP worksheet for hatchery operations since it does not deviate from the basic aim of HACCP, as it ensures food safety with the minimum necessary control at a smaller number (one) of CCPs. Wherever CPs are identified, the pre requisite control is indicated. The HACCP format developed by Codex was used for the hazard analysis. The hazard identification was based on the data collected from various reviews (Joshua et al. 1996, AAI 2002, MPEDA/NACA 2003, Ravichandran and Pillai 2004 and GESAMP 2005). The HACCP format developed by Codex was used for the hazard analysis. There is only one CCP identified, the raw material receiving step. Biological hazards like Virus could be carried with the broodstock. The control measure suggested is source control, i.e, only certified virus free stock should be used for further rearing. If gravid spawners collected from the sea are used for spawning, this step is regarded as a CCP, as the spawners could be virus carriers. Also, in the case of nauplii being purchased from others, stock tested to be virus free only should be used in order to avoid the vertical transmission of viral diseases. The biological hazard, WSSV identified at step 1 is regarded as a safety hazard and has been included under the HACCP plan. The physical and chemical hazards noticed at step 1 as well as all the other hazards identified under subsequent steps are either quality or hygiene related and hence assigned as non safety hazards and are included under the PRP plan. Stress and mortality are the physical hazards occurring at this step for which the preventive measures suggested are sticking to prescribed packing measures and limiting the transportation time to less than 8 hours. No significant chemical hazards are noticed at this stage. The hazards associated with broodstock acclimatization and disinfection are physical, chemical and biological. The biological hazards, bacteria and parasites which could be carried with the broodstock can be controlled by adherence to recommended chemical treatment procedures and specifications. For this purpose, usually an antibiotic, prophylactic dip treatment is given. Care should be taken to stick on to the recommended chemical treatment procedures and specifications. The physical hazards occurring at this step results from the hatchery rearing water and are the parameters, salinity, temperature, etc. which can be controlled by adherence to prescribed water quality specifications. Throughout the production process care should be taken to keep the contact surfaces, the water, the utensils etc. clean. The eggs may carry biological hazards like virus with them if the spawners were WSSV positive and subsequently carried over to the nauplii and PL. Water quality management, feed management, prophylactic treatments, sanitary and hygienic practices etc. have profound influence on the quality of production. The stress tests, suggested by many workers can be carried out at various points which are useful either at earlier stages as a predictive quality criterion or at later stages as a final PL quality criterion. The PL should be subjected to PCR tests before sales. The health status and the overall quality of the postlarvae is very important for the subsequent grow out operations. Hence weak and diseased larvae should not be sold.

8.6.4 HACCP Plan Form

Table 8.5 is the HACCP planform showing details of the CCPs, the type of hazard, critical limits, the monitoring personnel, parameters, method and frequency, corrective actions taken, documentation and verification. For every safety hazard identified, the HACCP plan must include critical limits, monitoring procedures, corrective actions and records to document that the process is in control.

8.6.4.1 Identification of control measures

More than one control measure may be required to control a specific hazard and more than one hazard may be controlled by a specific control measure. Examples of control measures are:

- Biological hazards. Time/temperature control, source control, hygienic practices
- Chemical hazards. Source control (vendor certification and raw materials testing), production control (proper use and application of food additives etc).
- Physical hazards. Source control, production control, use of metal detectors etc.

8.6.4.2 Critical limits

A critical limit is an established point, or tolerance which must not be exceeded, if a hazard is to be controlled at a CCP. It is a criterion which separates acceptability from unacceptability and there must be at least one critical limit for each hazard. This limit assures that the hazard is under control. If the limit has been exceeded, it is an indication that the hazard is out of control. Setting valid critical limits for safe management of CCPs requires some experimental activity and use of reference data (Mortimore 2001).

8.6.4.3 Monitoring

Monitoring ensures that the HACCP plan is working. Monitoring procedures can be either an observation or measurement and may involve qualitative or quantitative procedures. There are five main types of monitoring a CCP. They are visual observation, sensory evaluation, physical measurement, chemical testing and microbiological examination.

Table 8.5 HACCP Plan Form

(1)	(2)	(3)	(4)				(5)	(6)	(7)
Critical Control Point (CCP)	Significant Hazard(s)	Critical Limits for each Control Measure	Monitoring				Correct-ive Action	Records	Verifi-cation
			What	How	Frequency	Who			
Broodstock/ Spawners/ Nauplii selection	Viral diseases	Seeds tested for virus	PCR test Report From the supplier	Check of test report	Each lot	hatchery technician	Not accept Spawners/ seeds	Records of virus status for seeds	Check of records

8.6.5 The Process Control Model

Several studies have pointed out that HACCP is not a stand alone system,(NACMCF 1997, Sperber 2005b) though a tool for product safety management, it links with many other management systems and it can not be effectively implemented in the absence of some of these other management systems (Mortimore 2001) and that PRP are needed and can be used to work effectively with HACCP (Mortimore and Wallace 1998, Wallace and Williams 2001). Sperber (2005a) and many others have pointed out that food safety is assured by process control and not by finished product testing. The present study makes use of these approaches. Figure 8.4 is a representation of the process control operations taking place in a hatchery showing the CCPs and CPs being suggested to be controlled by HACCP and PRP respectively. It was based on the findings of the studies carried out from preparation of process flow chart through hazard analysis, determination of CPs and CCPs on the worksheet to HACCP planform and covered under 8.6.1 to 8.6.4, that the process control model illustrated in Fig.8.4 was developed. The quality or hygiene related hazards are included under the PRP plan and the safety hazards are included under the HACCP plan.

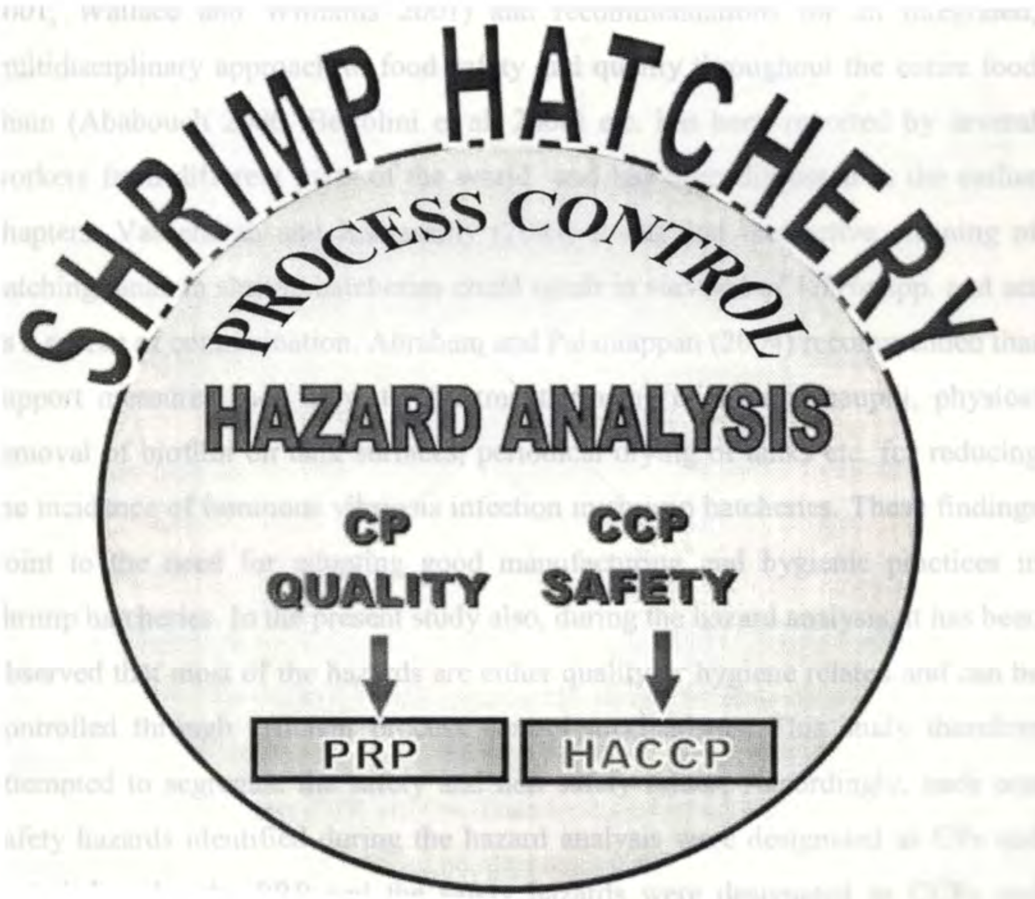

Fig.8.4 The process control model for the shrimp hatchery

8.7 <u>Safety and Quality under one umbrella</u>

The original concept of HACCP (Sperber 1991a, Bryan 1992), its expansion beyond the original concept to include the quality and hygiene issues which made HACCP less effective as a food safety control mechanism (Sperber 2005a) and the origin of PRP as support programs for the implementation of HACCP (Corlett 1998, Griffith 2000, Seward 2000, Billy 2002), the confusions and difficulties experienced in linking the concepts of HACCP PRP (Mortimore 2001, Vela and Fernandez 2003) which resulted in the search and development of models (Mortimore and Wallace 1998, Mortimore 2001, Wallace and Williams 2001) and recommendations for an integrated, multidisciplinary approach to food safety and quality throughout the entire food chain (Ababouch 2006, Bertolini et al. 2006) etc. has been reported by several workers from different parts of the world and has been discussed in the earlier chapters. Vaseeharan and Ramasamy (2003) found that ineffective cleaning of hatching tanks in shrimp hatcheries could result in survival of *Vibrio* spp. and act as a source of contamination. Abraham and Palaniappan (2004) recommended that support measures such as water treatment, rinsing of artemia nauplii, physical removal of biofilm on tank surfaces, periodical drying of tanks etc. for reducing the incidence of luminous vibriosis infection in shrimp hatcheries. These findings point to the need for adopting good manufacturing and hygienic practices in shrimp hatcheries. In the present study also, during the hazard analysis, it has been observed that most of the hazards are either quality or hygiene related and can be controlled through efficient process control mechanisms. This study therefore attempted to segregate the safety and non safety issues. Accordingly, such non safety hazards identified during the hazard analysis were designated as CPs and included under the PRP and the safety hazards were designated as CCPs and included under HACCP and illustrated in Fig.8.4 as the process control model. Wallace and Williams (2001) indicated that a prime difficulty encountered in designing and implementing a HACCP programme can be in deciding what constitutes HACCP and what constitutes GMP/ GHP. Taylor (2001) has indicated that the inability to prioritize the risks from physical, microbiological and chemical hazards results in confusion, overload and a dilution of control in small companies.

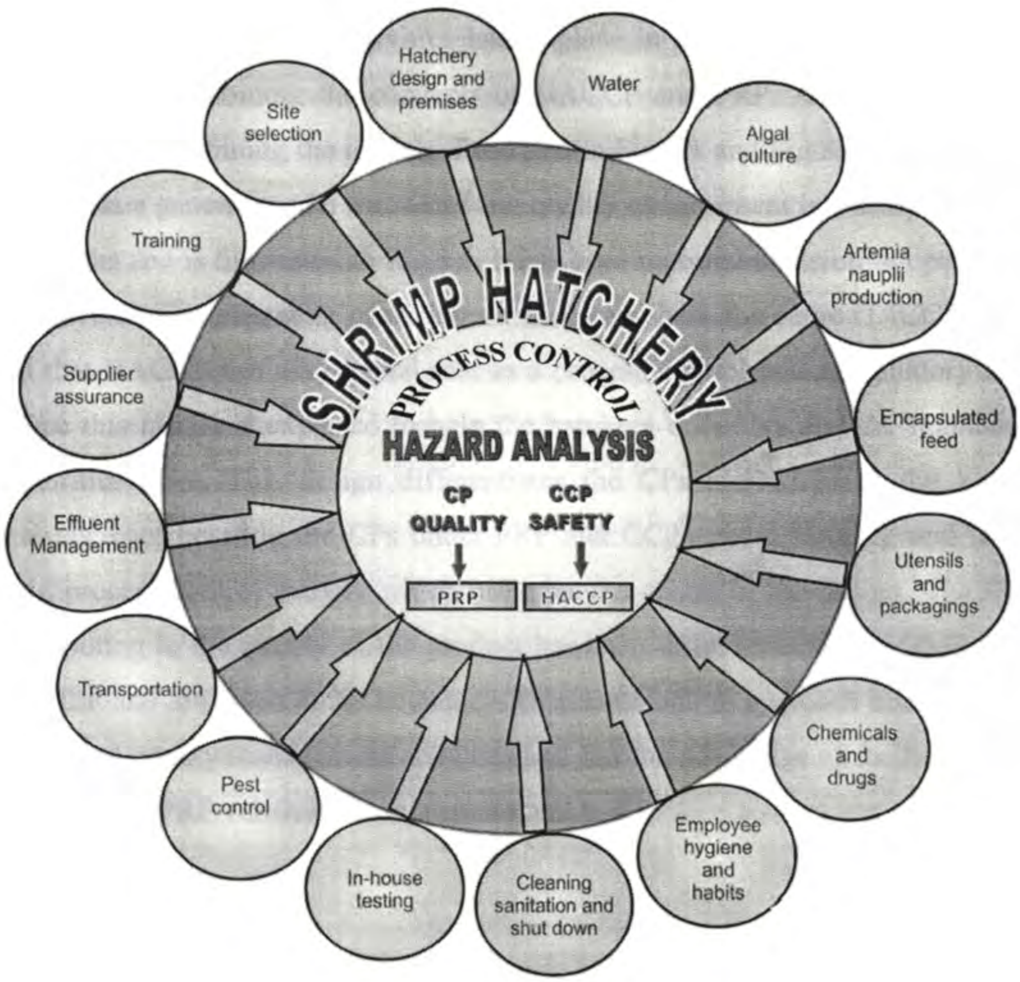

Fig.8.5 Safety and Quality management model for Shrimp hatchery

The GMP, GHP and GLP issues arising from the hatchery premises and processing aids and accessories were identified (8.3.1.1 to 8.3.1.16) and grouped under the PRP and is illustrated in Fig.8.1. The PRP provide the basic environmental and operating conditions that are necessary for the production of safe, wholesome food. The views expressed by different authors from different parts of the world suggest the need for applying PRP and HACCP in food service areas to ensure the safety of food consumption in the total food chain (Sperber 2005b, Sun and Ockerman 2005). The relationships of PRP and HACCP combined together for a total food safety and quality management system has been suggested by a few workers (Mortimore and Wallace 1998, Mortimore 2001, Wallace and Williams 2001) and are illustrated in Fig. 7.1, Fig. 7.7 and Fig. 7.8 respectively in Chapter 7. The present study, therefore is an attempt to unite the safety and quality control activities taking place in a shrimp hatchery under an umbrella, by combining the concepts of HACCP and PRP. A model has been designed by combining the models illustrated in Fig.8.1 and Fig.8.4 which can be adopted as a generic model for safety and quality management in shrimp hatchery operations and is illustrated in Fig.8.5. It has been reported that similar operations can have similar operating procedures which can share the same HACCP plans and that HACCP can play a dual role as a process control and a regulatory tool. Hence this model is expected to help the hatchery operators and the regulatory authorities alike. This design differentiates the CPs and CCPs in the hazard analysis, incorporating the CPs under PRP and CCPs under HACCP and is the main process control activity which occupies the centre of the design. The PRP contributing to the quality of the product has been differentiated into GMP,GHP and GLP and are given at the boundary. This combination approach integrates the safety and quality management activities and has the advantage of facilitating the HACCP and PRP verification on a concurrent basis.

8.8 Discussion

Studies have indicated that managers seemed to find it difficult to make their employees understand the importance of hazard analysis and why particular operations had to be monitored and controlled (Bas et al. 2007). Similar problems have been encountered in the present study also. However, in the present study, it was observed that the managers themselves were not convinced of the importance of hazard analysis and monitoring. The results obtained in the HACCP and PRP surveys conducted and discussed in Chapter 6 indicated that proper shrimp hatchery practices were often followed in most of the hatcheries studied in Kerala. However, this was never named or identified by them as pre requisite food safety programs for HACCP for want of training in PRP and

HACCP. Good structure, lay out and maintenance of the building, cleaning and sanitizing, personnel hygiene, pest/fly control, quality of water and chemicals, good live feed culture and laboratory practices etc. are essential for a hatchery to be considered as complying to the requirements of PRP. We currently have a sound base of good hygienic and good manufacturing practices, encompassing operations and facilities existing in the shrimp hatcheries in Kerala. However, there is need for training in the fundamental aspects of HACCP and PRP and record keeping. Ababouch (2000) points out that the HACCP approach requires food products to be prepared or processed in certified plants and establishments which requires that the plant meets minimal requirements in terms of layout, design and construction, hygiene and sanitation and suggests that the verification of PRP can be carried out concurrently with the HACCP assessment in order to have an overall assessment of safety and quality management. These quality assurance activities should be recorded, and communicated to the buyers through certification (Ababouch 2000). Proper understanding of HACCP and the related PRP by the hatchery operators as well as a commitment from the regulators and the Govt. is required to make HACCP successful. The role of management commitment in enhancing the effectiveness of HACCP has been highlighted (NACMCF 1998, Panisello and Quantick 2001). There are reports suggesting the integration of HACCP systems into quality management systems such as the ISO 9000 series mainly because management responsibility clearly appears within the elements of the ISO 9000 standards (Panisello and Quantick 2001). Taylor (2001) indicated that in small companies, the food safety must be ensured with minimum necessary control, with a small number of CCP's and with the necessary record keeping which can be integrated into the existing practice. In the present study, the managers revealed that they are afraid of the additional paper work and also that they will be overburdened with frequent inspections by the regulatory officials if HACCP is implemented. Taylor and Kane (2005) indicated that documentation and record keeping overburden most of the HACCP systems investigated.

8.9 Conclusion

In the present study, it was observed that most of the employees in the hatcheries including some managers were unaware of the importance of hazard analysis and monitoring and hence there is need for imparting training to the hatchery personnel on the fundamental aspects of HACCP. Since the broodstock or nauplii receiving step is identified as a CCP in a hatchery production process, the issue of non availability and high price of the spawners and nauplii could be a major hindrance to effective HACCP implementation in hatcheries. As the farmers are the loosers, as long as the hatchery production is not severely affected, the possibility of implementing HACCP in hatcheries on a voluntary basis can not be expected and the only pressure to apply HACCP for the hatcheries would be from legislation. Even though proper shrimp hatchery practices were often followed in most of the hatcheries studied in Kerala, this was never named or identified by them as pre requisite food safety programs for HACCP for want of training in PRP. In the present context of developments in international trade and tendencies leaning towards the requirement that imported foods should be produced or processed according to the HACCP system, if a developing country like ours fails to implement HACCP based systems in our food production or processing, we may have our shrimp exports rejected on the basis of inadequate food safety measures adopted and may cause negative economic consequences. Proper understanding of HACCP and the related PRP by the hatchery operators as well as a commitment from the regulators and the Govt. is required to make HACCP successful.

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Chapter - 9

SUMMARY, RECOMMENDATIONS AND CONCLUSION

9.1 Summary

The contents of this thesis is organized into nine chapters.

Chapter 1

The topic is introduced with in chapter one. The importance of aquaculture in the context of declining production from capture fisheries as well as increasing world population and undernourishment is discussed. The role of fish as one of the major protein sources for humans, the contribution, environmental impacts and constraints of aquaculture are analyzed. The concern about aquaculture whether it can increase global food security taking into account the inputs to aquaculture and the benefits of shrimp aquaculture in contributing to the export earnings are discussed. Chapter one closes with a brief mention on the scope and objectives of the present study.

Chapter 2

The literature review on the following aspects is presented in Chapter two. Throws light on the history of development of shrimp farming in the Asian region listing the top producers and dominant shrimp species cultured. The development of Shrimp Farming in India, the circumstances which led to the formulation of CRZ rules and the setting up of Aquaculture Authority, BMP in aquaculture and barriers to the adoption of BMPs and regulations for aquacultural effluents are discussed. The role of Aquaculture Legislation, the international, regional and national instruments and arrangements for maintaining aquatic animal health management etc. are reviewed. The status of hatcheries and their role in contributing to sustainable aquaculture production, nutrition and broodstock management, the environmental issues, effluent management in hatcheries are discussed with stress on the need for shrimp seed certification. The norms for registration of hatcheries, hatchery facilities required and the various hatchery management aspects are discussed.

The history of food safety and origin of HACCP and the emergence of modern HACCP system are reviewed. The evolution of global food safety systems, the seven principles of HACCP and the views of different authors regarding HACCP are presented. Development of HACCP in the United States, European Union and other countries as well as in India is reviewed. Concept and application of the HACCP approach, process of implementation of the HACCP system and benefits of HACCP system over traditional quality control systems are brought out. The farm to table food safety, genesis of the PRP, need for HACCP and PRP and development of safety and quality management systems are critically analyzed.

Chapter 3

In Chapter three, the methodology used for the surveys and analyses is discussed.

Chapter 4

Chapter four presents brief review of the studies conducted in shrimp farming operations, identifying the need for studies on the application of HACCP and PRP in shrimp farming operations. The HACCP and PRP knowledge, attitudes and behavior of selected farmers were evaluated. Non availability of good quality seed, low selling price, non availability of technical and financial support, environmental pollution, non awareness to proper dosage of chemicals and quality norms and standards etc. were the problems identified as key issues. The study indicated that most of the shrimp farmers were not aware of the HACCP principles, those who were aware had very little understanding. However, they were found to have a significant amount of knowledge in good aquacultural practices and the PRP adherence was found satisfactory. The main constraints to HACCP implementation identified were lack of motivation, lack of technical and financial support. Popularization of management approaches like BMPs and cluster management as well as need for research work on optimum nutrition and health management in the farming sector were suggested. This chapter concludes with the finding that proper PRP were followed in most of the shrimp farms studied.

Chapter 5

In chapter five, this study investigates the impact of farming environments on the quality and safety of farmed shrimp. The physico chemical and microbiological characteristics of selected brackish water shrimp farms and chemical and microbiological characteristics of shrimp cultured in these farms in three different districts in Kerala were studied. This study indicated that during brackish water aquaculture of shrimp, better care need to be taken to avoid contamination from the environment and suggests the implementation of better management approaches like HACCP to exercise control over food safety. The present study indicated that the farmed shrimp were cultured in unpolluted waters and are safe for consumption. It was also observed that the hazardous chemicals were within the permitted limits. The continuing threat of safety problems on our cultured shrimp, despite the mandatory imposition of HACCP in the seafood processing sector, points to the need for extension of this approach to the pre harvest culture operations.

Chapter 6

In chapter six, this study surveys the leading shrimp hatcheries in Kerala, explores the current shrimp hatchery practices, evaluates their adherence to HACCP and PRP principles and identifies the barriers to implementation of these concepts. The study becomes significant in the context of continuing deterioration of the quality of the hatchery produced seeds as well as disease outbreaks which have become very common. Though the understanding of the HACCP concept by the hatchery operators was poor, their PRP knowledge was good in most of the areas. The dependence on wild broodstocks, low selling price of the PL and non availability of technical assistance were identified as the major problems confronting this sector. Poor cleaning and sanitizing practices suggests the need for improvements in employee habits and sanitizing practices along with proper record keeping practices. There is need for ensuring the quality and safety of the hatchery seeds thereby protecting the farmers from economic fraud while ensuring a reasonable prize to the hatchery owner. The need for seed certification, fixation of uniform price and monitoring by regulatory agencies were recommended. Since the broodstock or nauplii receiving step is a CCP in a hatchery production process, the issue of non availability and high price of the spawners and nauplii could be a major hindrance to effective HACCP implementation in hatcheries. The hatchery operators had a higher level of HACCP awareness, compared to the shrimp farmers. The limited number of hatcheries, the hierarchial system prevailing in the hatcheries coupled with existence of proper guidelines for hatchery production and specifications for the seed and easy access to the hatcheries makes the verification by outside agencies easier. The present study also points to the need for strengthening the HACCP information dissemination systems available in our country since the inability of the usually conducted training programs in giving an in depth understanding of the concept or to motivate the individuals for self reading and improvement has been observed.

Chapter 7

In chapter seven, approaches to HACCP, PRP and safety and quality management by different authors have been presented. This study included PRP assessment of farm layout and facilities and separation of quality and hygiene hazards which may arise from the processing and surrounding environment. The hazard locations identified were listed on the flow chart, the

CCPs determined and developed the process control model representing the centre of activities of a shrimp farm incorporating the CCPs and CPs as well as made a comparison of similar studies coducted by other workers. Realizing that the concepts of HACCP and PRP were not clear to most of the respondents and that they fail to connect the two systems together, an attempt was made to bring the HACCP and PRP activities of shrimp farming operation under an umbrella, by co ordinating all the safety and quality control activities. Accordingly, a safety and quality management model was developed for shrimp farming operations by linking the concepts of HACCP and PRP which could guide the farmers and the HACCP practitioners through the HACCP process which can be adopted as a generic model for safety and quality management in shrimp farming operations.

Chapter 8

Chapter eight is an attempt to identify the various steps and the factors involved in the hatchery production of *P.monodon* postlarvae, differentiate the CCPs and CPs, segregate the HACCP and PRP aspects to unite and arrange them on a quality management wheel for the overall management of the shrimp hatchery operations. This chapter is introduced with the PRP assessment of the hatchery facilities and layout followed by the segregation of quality and hygiene hazards to be addressed through the PRP. The hazard identification, preparation of flow chart and the determination of CCPs were elaborated. The confusion prevailing among the hatchery operators with regard to PRP and HACCP plan, their relations and how they should be managed as revealed by the HACCP and PRP surveys and discussions with the hatchery operators, provided the background for this study and urged the need for an implementation model which could guide them in understanding and applying these concepts in their daily hatchery activities and thus ensure improvements in the quality and safety of the seeds raised. The model holds the PRP at the boundary and the process control activities at the centre with the CPs under the PRP and the CCPs under HACCP. The model designed is the result of the search for a united approach to safety and quality by combining the HACCP and PRP concepts. This combination approach integrates the safety and quality management activities of the shrimp hatchery operations and has the advantage of facilitating the HACCP and PRP verification on a concurrent basis. This model can be adopted as a generic model for safety and quality management in shrimp hatchery operations and is expected to help the hatchery operators and the regulatory authorities alike in a dual role as a process control and a regulatory tool.

Chapter 9

Summary, recommendations and conclusion are presented in Chapter nine.

9.2 Recommendations

- There is need for providing good quality, disease free PL to the shrimp farmers thereby facilitating elimination of infected and unhealthy larvae in the hatchery itself which could reduce the incidence of disease in grow out operations. Hence seed certification and regular monitoring by the regulatory authorities are important.

- Even though the implementation process of HACCP involves a sequence of steps in which the seven basic principles of HACCP are included, this study recommends the implementation of five stage HACCP in shrimp farming, using only five criteria instead of seven criteria, considering the position of our shrimp farmers that more than 90% of them are small scale farmers lacking proper HACCP knowledge and access to experts. Since the presence of pre requisite practices were identified, five stage HACCP can be implemented with appropriate source control for the CCPs identified. For this certified seed and feed are essential. However, in hatcheries, implementation of seven-stage HACCP is recommended. Instead of allowing foreign agencies for the process of certification, services of the experts from our state can be availed.

- Non availability and higher price for the broodstock were the most important problem confronting the hatchery sector which forces the hatchery operators to procure nauplii from other states. Therefore, upgradation of one or two hatcheries in the public sector into master hatcheries with hi tech infrastructure and R&D facilities for the purpose of supplying nauplii to hatcheries in the state at cost price and for utilization of excess production in the hatcheries for supporting stock enhancement activities is recommended.

- The sustainability of the practice of harvesting wild broodstock spawners and wild PL is under threat. Hence there is need for regulation of broodstock capture fisheries and encouragement of captive breeding techniques.

- Slight variations are observed with respect to the farming practices in different regions. However, standard flow charts and work sheets prepared in this study can be introduced. Layout and premises studies showed that the arrangement of farms in certain areas causes cross contamination leading to contamination of the main intake sources. The common water intake canals were observed to be in blocked condition, so the local administration should be properly instructed to carry out the clearing jobs. Constant monitoring and surveillance of the quality and safety of coastal waters and shrimp samples by the regulatory authorities is suggested.

- Govt. support is needed for the upgradation of hiring centers for ice, krates, vehicles and other accessories for post harvest handling. The post harvest handling aids are most often found dirty and the quality of water used for ice manufacture is also not satisfactory and need to be improved. Common freezing and storage facilities should be provided at regions where marginal farmers concentrate which will also improve their bargaining power.

- Middlemen such as traders, suppliers and salesmen were found to have an important role in exchanging and disseminating information on safe and effective use of chemicals. Hence it is essential that information on safe and effective use of chemicals through training should be extended not only to hatchery and farm operators but also to these people. This study awareness of the hatchery operators was higher with respect to information on HACCP and PRP. Major constraints faced by the farming and hatchery sectors were identified and suitable remedial measures suggested. These surveys also revealed that there is a confusion prevailing among the respondents with respect to the concepts and relations of PRP and HACCP and how they should be applied and managed in a system. Chapters seven and eight apply these information into their specific needs, examine the possibility of application of the concepts of PRP and HACCP, identify the ways in which PRP could be a basic constituent of safety itself and an enabling key to total quality management and ventures into designing models for guiding the shrimp farmers and hatchery operators through the HACCP process. The role of PRP as a support system for HACCP has been clearly brought out in this study. The reviews available on HACCP and PRP are mostly authored by foreign publishers which makes easy reading impossible by layperson. This work critically analyses the views presented by different workers and reiterates the advantages of an integrated move involving PRP and HACCP in support of the argument that while improving the quality is important, enhancing the safety is critical. This study also points to the need for capacity building of HACCP extension personnel thereby strengthening the HACCP information dissemination systems available in our country.

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APPENDIX-1

PRP QUESTIONNAIRE FOR SHRIMP FARMERS

District :

1. Name and address
2. Nature of the farm (Proprietary, Partnership, Public Ltd)
3. Title/ right of the property (Owned / Leased in)
4. Total culturable area owned by the person
5. Farm water spread area
6. Have you registered with AAI ?
7. Year of establishment
8. Educational level
9. Age group
10. Experience
11. Carrying capacity of the farming zone to which you belong to
12. Location of the farm (Good, Satisfactory, Bad)
13. Surroundings (Good, Satisfactory, Bad)
14. Is shrimp farming your main occupation (yes / no)
15. Is there any shrimp farmers association or cooperatives in your village ? (yes/no)
16. Are you a member of the society? (yes/no)
17. Are you satisfied with the functioning of the association ? (yes/no)
18. Whether adequate water supply is available (yes/no)
19. Nature of soil (Acidic / Alkaline / Salty)
20. Whether the sand is suitable for (aquaculture / agriculture/ both)
21. Source of electricity (Agricultural /Industrial)
22. No. of crops per year
23. No. of days in a crop cycle

24. Carrying capacity of your farm
25. Total number of employees
26. Number of persons / shift
27. Number of shifts
28. Details of equipments
29. Expenditure (per crop)

Pond preparation

1. Where do you dispose the bottom sludge? (By the side of the pond, in a trench dug along the bund, Outside the pond)
2. Whether the sludge is removed; (Manually, Mechanically)
3. Black soil is an indication of poor bottom soil quality; (Yes / No)
4. The optimum soil PH for shrimp culture should be above 6 (Yes / No)
5. What is the condition of the soil while ploughing ? (Dry , Wet)
6. Ploughing on wet soil is the recommended practice (Yes / No)
7. Do you dry the pond bottom after ploughing? (Yes / No)
8. How many days the pond bottom is allowed to dry; (5-7, 7-15, 15-21)
9. Whether compaction of the bottom is done after the pond preparation; (Yes / No)
10. Compaction avoids turbid water conditions during culture period: (Yes / No)
11. Do you check the soil PH and pond water PH before the application of lime? (Yes / No)
12. Whether the PH is checked by using: (PH meter, PH indicator solutions, PH papers)
13. Liming during pond preparation optimizes PH and alkalinity conditions of soil and water(Yes / No)
14. There are recommended levels for lime application (Yes / No)
15. Quick lime or hydrated lime is used only when the soil PH is <5 (Yes / No)
16. Shell lime, agricultural lime or dolomite is used if the soil PH is >5 (Yes, No)
17. In acid sulfate soil, the lime is applied after filling the pond with water (Yes / No)

18. In case of disinfecting, which is applied first (Lime, Disinfectant)
19. Whether the influent water is filtered (Yes / No)
20. What is the mesh size of the filter used?
21. Are you using water from the reservoir or directly?
22. Keeping in reservoirs improve the water quality(Yes / No)
23. How long the water is to be kept in reservoirs before pumping into the farm?
24. The grow-out ponds should be filled at least 14 days before stocking (Yes / No)
25. The optimum water depth in the pond should be 1.2m (Yes / No)
26. Whether the foot valve of the suction line is kept sufficiently (half a foot) above the pond bottom (Yes / No)

Fertilization

1. Fertilization increases production of natural food in shrimp ponds (Yes/ No)
2. Extensive culture systems rely completely on the natural productivity and fertilizers (Yes / No)
3. Green algae reduces stress on shrimp PL and prevents growth of harmful benthic algae in the pond bottom(Yes / No)
4. Green algae prevents sunlight touching the pond bottom (Yes / No)
5. A heavy bloom ultimately leads to a collapse (Yes / No)
6. Green water ponds have better production and lower risk of disease outbreaks(Y es / No)
7. Higher nutrient load and less water exchange may lead to excessive algal bloom(Yes / No)
8. Quantity of cowdung used per ha (300-500kg)
9. Organic fertilizers like fresh cowdung may contaminate the pond water (Yes / No)
10. Are you using any inorganic fertilizers like urea or superphosphate (Yes / No)
11. What is the quantity used per ha (30-50kg)
12. Fertilisation is done 10 days before stocking (Yes / No)

13. Do you know that organic fertilizers like cowdung or chicken manure gives a stable bloom (Yes / No)
14. Inorganic fertilizers result in sudden development and crash of bloom (Yes / No)
15. Mixed fertilization is the best method (Yes / No)
16. Semi intensive culture systems require a combination of fertilizers and supplemental feeds (Yes / No)

Seed and seeding

1. Whether the seed is procured from hatchery or nursery
2. Do you carry out the PCR test before purchasing the seed (Yes / No)
3. No. of PL used for PCR test (59, <59, >59,)
4. Prevalence of WSSV in the seed tested usually (5%, <5%, >5%)
5. Transportation time from hatchery to farm (6hrs, >6hrs, <6hrs)
6. What is the mortality rate during transportation ?
7. Colour of the seed
8. Size of juveniles (16mm, 10-15mm, 15-20mm)
9. Age of the seed
10. Quality of the seed (active, less active)
11. Stocking density ; (3-5, 5-7, 6-8, 8-10 PL/ m^2)
12. Are you transporting the seeds in transportation bags? (Yes / No)
13. Do you know that there are recommended densities of seeds in transportation bags?
14. Do you separate the weak seeds before stocking/ (Yes / No)
15. Do you employ any formalin treatment ? (Yes / No)
16. What is the concentration and dipping time?
17. Do you know that it is 100ppm for 30minutes in the case of hatchery procured seeds (Yes / No)
18. Do you know that it is 150ppm for 15minutes in the case of nursery procured seeds (Yes / No)
19. Do you know that the formalin treatment should be done along with aeration?(Yes / No)

20. Do you know that the formalin treatment should not be done if the PL are moulting (Yes / No)

21. The formalin treatment is helpful in reducing the external parasites and fouling (Yes / No)

22. Do you acclimatize the PL to the pond water conditions before stocking (Yes / No)

Water quality management

1. Do you know that the water exchange should not exceed 30% of water in the pond
2. (Yes / No)
3. Do you know that the ideal water exchange should be 10% of water in the pond
4. (Yes / No)
5. Do you know that it changes algal blooms, PH, salinity etc. (Yes / No)
6. The water depth in the shallowest part of the pond should be at least 80cm(Yes / No)
7. Is the water inlet and outlet screened (Yes / No)
8. Do you know that PH above 8.5 is not favourable for shrimp farming (Yes / No)
9. How do you adjust the changes in PH (by water exchange, by application of lime)
10. Are you using probiotics, zeolite, BKC, iodine etc. (Yes / No)
11. What are the water quality parameters evaluated daily (PH, Temp., Colour, transparency)
12. How often do you check the alkalinity?
13. Low alkalinity and algal blooms can change the PH suddenly (Yes / No)
14. It is easier to control the water quality in low salinity areas (Yes / No)
15. Whether other water quality evaluation tests done (TSS, BOD, COD, DO, TN, TP)
16. Do you know the recommended ranges of values for these? (Yes / No)
17. The level of total ammonia nitrogen should not exceed 1ppm at a PH of 8.5 (Yes / No)

18. Are you providing aeration ? (Yes / No)
19. When is the aeration employed? (morning, evening, morning to evening, evening to morning)
20. Do you know that aeration should be provided after 30 days of culture when the stocking density exceeds 6Shrimp / m^2 (Yes / No)
21. Aeration is applied when(Shrimps start surfacing, Bottom soil quality is bad, Water becomes turbid and dark in colour)
22. How often do you check the pond bottom soil (Daily, Weekly, Monthly)
23. Whether the soil is examined for (black soil, benthic algae, bad smell)
24. Do you know that low dissolved Oxygen is mainly the result of organic wastes at the pond bottom (Yes / No)
25. Black and toxic bottom sediments adversely affect shrimp health (Yes / No)
26. What do you usually do if the shrimp is found to come to the water surface unusually?
27. Do you use any antibiotics (Yes / No)
28. Prophylactic treatments should be avoided due to the chance for development of antibacterial resistance (Yes / No)
29. The effluents containing chemical residues should not be discharged to natural water
bodies (Yes / No)

Feed Management

1. Intensive culture systems rely heavily on feeds and require less input of fertilizers(Yes / No)
2. Sources of feed: a) Within the state( ) Outside the state( ) b) (Direct, supplier, both)
3. Do you evaluate the suppliers according to the feed quality,availability, rate etc(Yes / No)
4. Are your suppliers able to supply adequate quantity of feed at the right time (Yes / No)
5. Does the farm maintain adequate reserve stock of feed ? (Yes/No)
6. No. of feed suppliers (single / many)

7. Are the feed suppliers registered? (Yes/ No/ do not know)
8. Do you test the feed before or after purchasing? (Yes/No)
9. What is the type of arrangement with your suppliers?
10. Do you give medicated feed? (Yes/No)
11. Is the feed completely taken (Always / often / sometimes)
12. Types of feed used : (cut fish/ artificial)
13. Whether pellet feeding is employed (Yes / No)
14. Are you following the feed tables supplied by the feed manufacturers (Yes / No)
15. Whether meal quantity is decided on the basis of (body weight of shrimp, feed tray result, both)
16. Whether mixing two feed pellet sizes done (Yes / No)
17. When is the feed trays first introduced (after one week of stocking?) (Yes / No)
18. Is it also used for checking the general condition of shrimp (Yes / No)
19. How often do you change the feeding area (once in 10 days, 15, 20)
20. Whether the feeds are stored properly
21. Length of storage of feeds:
22. Do you keep any feed records ? (Yes / No)
23. Do you know that antibiotics and a range of probiotics have no significant effect on the risk of shrimp disease outbreaks (Yes / No)
24. Lime, fertilizers and disinfectants have some protective effect against shrimp diseases (Yes / No)
25. Feed additives including vitamin and mineral premix and some bacterial products have some beneficial effect on shrimp production (Yes / No)
26. Pesticides and antibiotics lead to residues in harvested shrimp (Yes / No)
27. Fertilizers, lime, zeolite and related compounds do not lead to residues in harvested shrimp (Yes / No)

Chemicals Management

1. EDTA can reduce the bioavailability of heavy metals by complexation(Yes / No)
2. Zeolites are tectosilicate minerals applied to shrimp ponds to remove ammonia (Yes / No)
3. Zeolite is applied at a dose of 100-500kg/ha (Yes / No)
4. Fertilizers if used indiscriminately can cause deterioration of soil and water conditions(Yes No)
5. Chlorine decays with time by the action of sunlight and by use for oxidation of organic matter (Yes / No)
6. Release of chlorinated water to the receiving water body can cause localized biological effects (Yes / No)
7. Iodophores are widely used as disinfectants in shrimp farming (Yes / No)
8. Quaternary ammonium compounds like BKC have detergent and antibacterial activity and are widely used as bactericides and fungicides (Yes / No)
9. Use and ingestion of chloramphenicol in humans is associated with aplastic anaemia (Yes / No)
10. The major environmental hazard of chloramphenicol is its potential to increase drug resistance (Yes / No)
11. Antibacterial agents like nitrofurans are potential carcinogens (Yes / No)
12. The use of some drugs like chloramphenicol are banned in aquaculture (Yes /No)
13. Whether the enforcement of such bans is existent, weak or non-existent in your region(Yes / No)
14. Do you think such regulations are to be strengthened for better consumer protection (Yes/No)
15. Is there proper surveillance programmes to monitor compliance with limits on tissue residues (Yes / No)
16. Treatment concentrations of chemicals are as per instructions on the product (Yes / No)
17. Formalin is a potential carcinogen and should be handled carefully

(Yes / No)

18. Malachite green is widely used as an antifungal and antiprotozoan agent (Yes / No)
19. Malachite green is a respiratory enzyme poison and lengthy withdrawal period is needed following its application (Yes / No)
20. Treflan is the most commonly used prophylactic fungicide in shrimp hatcheries (Yes / No)
21. Ammonia and Saponin are widely used in shrimp culture as piscicides prior to stocking (Yes / No)
22. Vitamin C has got widespread use as a feed supplement (Yes / No)
23. Tiger shrimp with ascorbic acid deficiency show moulting incompetence, malformation of carapace, disorder of the gill and associated high mortality (Yes / No)
24. Do you use any chemicals like astaxanthin during growth phase for the artificial colouration of shrimp flesh (Yes / No)

Do you know

25. The importing countries are imposing restrictions on compounds used by the shrimp farmers in the exporting countries and have introduced residue monitoring programmes for imports (Yes / No)
26. When an animal is treated with any chemical for therapeutic or other purposes, either by bath, oral or via injection, the chemical will generally be absorbed by the animal concerned(Yes / No)
27. MRL is the maximum concentration of residue considered to be without any significant toxicological risk for human health resulting from the use of a drug that is recognized as acceptable in food (Yes / No)
28. Withdrawal period is the time delay between cessation of therapy and harvesting (Yes / No)
29. There is potential for some chemical compounds used in aquaculture to pose health risks to farm workers (Yes / No)
30. Are the farm workers properly trained to handle chemicals (Yes / No)
31. Whether the chemicals are stored properly (Yes / No)

32. Is there any recommended practices for the application and use of chemicals (Yes / No)

33. Do you keep records regarding use of chemicals,daily checks and observations etc.(Yes / No)

Disease management

1. How many times the shrimp is examined daily? (Morning / Evening / both)
2. Peak disease season, if any noticed.
3. Major disease problems faced: (WSD, Vibriosis, Loose shell syndrome)
4. WSSV is the necessary cause of WSD (Yes / No)
5. WSSV alone can't bring out a WSD outbreak in the pond (Yes / No)
6. WSSV can enter the shrimp and the pond through different routes (Yes / No)
7. Good pond management practices can reduce the risks of WSD (Yes / No)
8. Loose shell syndrome is a bacterial infection (Yes / No)
9. Viral diseases like WSD can't be treated by antibiotics (Yes / No)
10. Vibriosis called 'one month mortality syndrome' is caused by vibrios (Yes / No)
11. HPV attacking the hepatopancrease of shrimp will cause slow or stunded growth(Yes / No)
12. Have you noticed any relation between WSSV and temperature? (Yes / No)
13. What measures are taken for preventing spreading of diseases(isolate the pond, inform the neighbouring farmers, net harvest the shrimp, disinfect the pond before discharging the water)
14. Do you treat the effluent before discharging into the water supply? (Yes / No)

Harvesting

1. What is the average size of shrimp at harvest
2. Gear used for harvesting?
3. Time taken for harvesting (2-4 hrd; 4-6 hrs; 6-8 hrs; above 8 hrs)

4. What is the source of water used for washing the catch? (Well water, Public tap, Others)
5. What is the source of ice?
6. How many ice plants are there in your Panchayat?
7. What is the source of water used in the ice plant?
8. Is there any kind of monitoring system in the ice plant?
9. What is the type of ice used? (Block; Tube; Flake)
10. Icing ratio; (1:1, 1:2, 1:3)
11. Whether the raw material is kept in plastic krates, ss vessels or others
12. Are you using chlorinated water for washing the shrimp (Yes / No)
13. Chlorination levels (1-2 ppm; 2-5 ppm; 5-10ppm)
14. Do you employ any metabisulphite treatments? (Yes / No)
15. What is the concentration and dipping time?
16. Who is supervising the icing and the treatment processes ?
17. Assessment of raw material quality is by (Sensory method, chemical, Microbiological, Physical)
18. Raw material temperature (Upto +5°C +5-10°C Above +10°C)
19. Raw material texture (Soft, Hard , Rubbery)
20. What is the time lag between harvest and despatch of the raw material? (Upto 2 hrs, 2-4 hrs, 4-6 hrs, above 6 hrs)
21. Do you encounter any quality problems in the shrimp raised ?
22. Are you satisfied with the present level of production output ?
23. What is the peak season of demand for your product ?
24. Is the buyer and the price pre fixed? (Always, sometimes, never)

Facility

1. Adequate water exchange facilities
2. Surroundings maintained in good condition
3. Temperature and PH recording measures
4. Storage facilities for feed, chemicals and other things
5. Do you calibrate your thermometer and PH meter

General

1. Do you possess a GAP (Good Aquacultural Practices) manual (Yes / No)
2. Do you possess any literature on shrimp farming / shrimp health management(Yes / No)
3. Do you know there are standards for aquacultural inputs (Yes / No)
4. Do you know there are guidelines for effluent treatment (Yes / No)
5. Have you undergone any training in any aspects of shrimp farming (Yes / No)
6. Which agency provide you with the necessary technical support (Govt. , Private, both)
7. Have you got any financial assistance from the Govt. or Govt. agencies (MPEDA, BFFDA, ADAK)
8. Have you heard about the recently enforced Coastal Regulations and Management Plans in your Panchayat ? (Yes / No)
9. Whether HACCP plan is implemented ? (Yes / No)
10. Are the CPs and CCPs clearly demarcated? (Yes / No)
11. Are there effective monitoring procedures? (Yes / No)
12. Whether corrective action techniques are satisfactory ? (Yes / No)
13. Are there record keeping procedures ? (Yes / No)
14. Are you satisfied with the present quality control set up ? (Yes / No)
15. What are the factors influencing quality? (seed, feed, water quality, all these)
16. Are you aware of the latest developments in the field of quality assurance in seafood in India and abroad ? (Yes / No)
17. Do you monitor the cost components regularly? (Yes / No)
18. What are the problems faced by you in this field ?
19. Whether any type of support is needed (Research, credit, training, infrastructural, financial)

Signature

Date

APPENDIX-II

PRP QUESTIONNAIRE FOR THE SHRIMP HATCHERIES

General

1. Name and address
2. Nature of the firm (proprietary, partnership, public Ltd)
3. Title/ right of the property (Owned / Leased in)
4. Have you registered with any agency (Yes/No)
5. Year of establishment
6. Total area
7. Educational level
8. Age group
9. Experience
10. Is there any shrimp hatchery owner's association in your district or state (Yes/No)
11. Are you a member ? (Yes/No)
12. Total number of employees
13. Number of persons per shift

Geographical location

1. Location of the hatchery (Good, Satisfactory, Bad)
2. Surroundings (Good, Satisfactory, Bad)
3. Whether good quality seawater is available (Yes/No)
4. How far is the seawater inlet from the hatchery?
5. Whether the climatic conditions are suitable (Yes/No)

Broodstock management

1. Is the broodstock available year round (Yes/No)
2. Transportation time from landing centre to hatchery

3. Average price of the spawners
4. Length/ weight of spawners/ brooders
5. Do you acclimatise the spawners before release into the maturation tank (Yes/No)
6. Whether they are disinfected (Yes/No)
7. If yes, what is the concentration and dipping time
8. Whether any antibiotic dip treatment is given (Yes/No)
9. What is the stocking density of the brooders (6-7 per m^2)
10. What is the sex ratio at stocking(1:1)
11. How much is the water depth in the maturation tanks (60 cm)
12. The water exchange percentage (200%)
13. What all precautions do you take to maintain the noise and disturbance to the minimum
14. What are the water quality parameters checked (salinity, temp. and PH)
15. Are you using any cartridge filters for the breeding section (Yes/No)
16. What are the feeds given (squid, beef liver, clams, shrimps, polychaetes etc)
17. The feed quantity is 12% of the estimated shrimp biomass (Yes/No)
18. Details of the prophylactic and therapeutic treatments given;
19. What are the antibiotics used (chloramphenicol, prefuran, erythromycin, oxytetracycline)
20. How many times a day the siphoning is done (morning and evening)
21. Soft (moulted) females are not taken for eyestalk ablation (Yes/No)
22. Are the ablated females put in antibiotic solution before transfering to the maturation tanks (Yes/No)
23. How do you identify the potential spawners(by the thickening of the ovary and a diamond pattern in the first abdominal segment)

Spawning and Hatching Management

1. Whether the water in the spawning tank is treated (Yes/No)
2. If yes, upto what level it is treated
3. Good eggs will appear as a greenish granular accumulation at the bottom of the tank (Yes/No)

4. What is the mesh size of the hand net used for harvesting the eggs (350 micron) What is the mesh size of the harvesting bucket used for siphoning the eggs (100 micron)
5. The fertilized eggs can be identified by the symmetrical nature of cell divisions as well as by the presence of appendages and setae (Yes/No)
6. The unfertilized eggs appear as opaque or dark brown spheres with irregular cell divisions (Yes/No)
7. The fertility % usually obtained
8. How much volume of egg water is used for counting the eggs ?
9. Whether the water in the hatching tanks are treated (Yes/No)
10. The aeration in the hatching tanks are kept to a minimum level (Yes/No)
11. What is the optimum temp and salinity required for the nauplii(28-320c and 29-34ppt)
12. The time lag required for the nauplii to reach the 6^{th} sub stage, N6 (36 hours)
13. What is the mesh size of the harvesting bucket used for harvesting of nauplii (100 micron)
14. The nauplii are attracted towards the light (Yes/No)
15. It is preferable to reject nauplii produced from spawns with hatching rate below 40%
16. The nauplii that are not active and do not show a fairly regular rhythm of swimming and positive phototaxis also has to be rejected
17. The nauplii with physical deformities such as incompletely formed appendages and setae, twisted setae and those with accumulation of dirt also should be discarded
18. The nauplii pass through three zoeal and three mysis stages before they reach post larval stage

Larval management

1. Larval stages are critical and sensitive phases of shrimp life cycle
2. The adult P.monodon mature, mate and release eggs in the deep oceanic waters

3. The hatched out larvae dwell in the surface waters of the ocean till they reach the PL stage
4. The Post larvae grow to sub adult stage in coastal, brackish waters
5. Coastal, brackish waters have a salinity of 5 to 25 ppt whereas oceanic waters have a salinity of 28 to 35 ppt.
6. The larval phases of P.monodon needs an oceanic environment with a salinity of 28 to 35 ppt.
7. The nauplii can subsist on yolk (Yes/No)
8. The zoea feeds on phytoplankton (Yes/No)
9. Zoea is the first feeding stage (Yes/No)
10. Mysis feeds on phytoplankton and zooplankton (Yes/No)
11. The recommended stocking density of nauplii is 100, 000/ ton.
12. At what stage do you start artificial pellet feeding (from mysis stage onwards)
13. How long is the post larvae reared in the larval section (upto PL 3 to 5)
14. The larval rearing from N6 to PL 3 takes 13 days (Yes/No)
15. Do you properly record the salinity, temp. and PH. (Yes/No)
16. Are you facing any temp. fluctuation problems (Yes/No)
17. Are you using any thermostatically controlled insulated immersion water heaters (Yes/No)
18. Are you passing the seawater through electrical heating systems before filling the tanks (Yes/No)
19. Whether the room is provided with shade clothes over the tanks to prevent direct sunlight from entering the tanks (Yes/No)
20. The recommended range of seawater PH for a shrimp hatchery is 8.2-8.5(Yes / No)
21. .Is the larval rearing room isolated from other sections to avoid cross contamination
22. (Yes / No)
23. The PL should be transferred to the post-larval section at PL-3 stage (Yes / No)

Post larval management

1. Do you acclimatise the PL before leaving into the tank (Yes/No)
2. Which type of tanks are used for rearing PL (reinforced concrete tanks of 20 ton capacity)
3. Whether the inner surface of the tanks are coated with food grade epoxy paints (Yes/No)
4. What is the stoking density of post larvae (25-50/lit)
5. Healthy post larvae appear to be clean, active, with full guts and well developed tail muscle.
6. Whether filtered, chlorinated, dechlorinated, EDTA treated water is used for larval rearing (Yes / No)
7. Whether filtered, dust and oil free air is used for aeration (Yes / No)
8. Do you know that there is a formula for estimating the number of eggs, nauplii, PL etc. in the tank (Yes / No)
9. The recommended salinity range for a shrimp hatchery is 28-35 ppt. (Yes / No)
10. The recommended range of seawater temp. for a shrimp hatchery is 280c-320c.
11. (Yes / No)
12. The recommended range of seawater PH for a shrimp hatchery is 8.2-8.5(Yes / No)
13. Aeration helps to keep optimum dissolved oxygen levels and proper circulation of water for facilitating availability of feed to larvae (Yes/No)
14. Feeding is one of the important factors determining the growth of larvae (Yes/No)
15. What types of feeds are given to the post larvae (Artemia, Micro-encapsulated diet, Egg custard)
16. When do you start giving the egg custard (from PL8 onwards)
17. What is the optimum temp required for the PL(28-10c) 29-34ppt)
18. What is the optimum salinity required for the PL (31.5-1.5 ppt)
19. What is the optimum PH required for the PL(8.2)

20. Whether the water is treated with an antibiotic and 0.05 ppm Treflan as prophylaxis (Yes/No)
21. How often do you test the water sample in a recognised laboratory (annually, half yearly, never)
22. Whether the waste materials are siphoned out daily (Yes/No)
23. What will be the size of 20 days old PL (13 mm)
24. The viability of the hatchery depends on the cost of prodution of post larvae (Yes/No)

Feed Management

1. Sources of feed (within the state, outside the state)
2. Do you import any of the feeds (Yes/No)
3. Do you test the feeds before or after purchasing (Yes/No)
4. Are you following the feed tables supplied by the feed manufacturers (Yes / No)
5. What types of feeds are given ?(Algae, Artemia, Micro encapsulated diets)
6. Is there an algal rearing section in your hatchery (Yes/No)
7. Zoeal stages are given only algae
8. Mysis and PLs need Artemia nauplii along with algae
9. Algae has to be fed after water exchange and in the evening at 3 P.M (Yes/No)
10. Do you estimate the residual algal cell density using a haemocytometer (Yes/No)
11. Cysts and cyst shells if introduced along with artemia nauplii may bring bacteria into the larval tank (Yes/No)
12. Do you think that supplementary feeds along with natural diets are needed for faster and healthy growth (Yes/No)
13. Are you using supplementary feeds as substitutes for natural feeds during periods of scarcity and vice versa (Yes/No)
14. What is the capsule size of micro encapsulated diets suitable for zoea (5-30 microns)
15. What is the capsule size of micro encapsulated diets suitable for mysis (40-90 microns)

16. What is the capsule size of micro encapsulated diets suitable for PL (90-150 microns)
17. Whether mixing of two feed pellet sizes done (Yes / No)
18. Is the feed mixed with water before feeding (Yes/No)
19. How many times a day the feed is given (6 A.M, 1 P.M, 5 P.M and !0 P.M.)

Algal culture

1. Which one is the best suitable algal species for P. monodon hatchery (Chaetoceros)
2. What is the recommended range of light intensity for good algal growth(1000-8000 lux)
3. What is the recommended temp. range for healthy and fast growth of algae(24-260c)
4. Aeration is necessary to keep the algae in suspension, to supply CO_2 needed for growth and to stabilize PH (Yes/No)
5. Temp has a pronounced influence on photosynthesis, respiration and other metabolic activities of algae (Yes/No)
6. Whether the algal culture room is isolated from other sections of the hatchery (Yes/No)
7. Are you using filtered and chlorinated seawater for algal culture (Yes/No)
8. Whether you are isolating pure algal strain from the sea water or purchasing it
9. What is the price (Rs.300/25ml)
10. How many days do you store the stock culture(15 days)
11. How many days before the acquisition of gravid shrimp, do you start mass culture of algae (one month before)
12. Prolonged culture results in a decrease in size and nutritive value (Yes/No)
13. Vitamins are added to the autoclaved and cooled F/2 medium just before inoculation (Yes/No)
14. Whether ten percent inoculum is required at all culture levels to get the desirable cell density (Yes/No)
15. Are you recording the microscopic observation details, salinity, temp.etc. in a daily data sheet (Yes/No)

16. Are you maintaining a material consumption record (Yes/No)

Artemia cyst Hatching

1. Artemia can survive in salinities of 150-200ppt , but resorts to encystment of the embryo at gastrula stage (Yes/No)
2. How long the artemia cysts can usually be preserved (8-12 months)
3. What is the hatching time of artemia cysts (24-36hrs)
4. Which type of tanks are used for culture of artemia (fibre glass tanks of 450 lit capacity)
5. The optimum salinity required for efficient hatching of artemia cysts is 25-35ppt (Yes/No)
6. The optimum temperature required for efficient hatching of artemia cysts is 28-320c (Yes/No)
7. The optimum PH required for efficient hatching of artemia cysts is 8.0-8.5 (Yes/No)
8. The optimum light intensity required for efficient hatching of artemia cysts is 2000 lux (Yes/No)
9. Whether continuous aeration is required for efficient hatching of artemia cysts (Yes/No)
10. Are you using special FRP tanks with transparent conical bottom for hatching of artemia cysts (Yes/No)
11. Whether the tank is provided with continuous aeration and fluorescent lights above it
12. Do you disinfect the artemia cysts in chlorine before stocking in the hatching tanks (Yes/No)
13. If so, what is the concentration and dipping time (200ppm for 15 minutes)
14. What is the stocking density of artemia cysts (1-2 g/l)
15. How is the nauplii separated from hatched shells and unhatched cysts ?
16. The unhatched cysts will settle at the bottom and the unhatched shells will float at the surface (Yes/No)
17. The harvested nauplii should be thoroughly washed in seawater before feeding to the PL (Yes/No)
18. Do you estimate the hatching efficiency and population density? (Yes/No)

19. Do you keep a record of all these? (Yes/No)

Seawater Quality Management

1. Are you passing the sea water through a filter bed before it is collected and pumped into the reservoir (Yes/No)
2. Upto what level the water is chlorinated? (5-10 ppm)
3. Whether the water is filtered using rapid and slow sand filters(50u) (Yes/No)
4. Are you checking the residual chlorination with the help of chlorine test kits (Yes/No)
5. Do you allow at least one hour settlement time after adding EDTA (Yes/No)
6. What is the concentration of EDTA applied (10ppm)
7. What are the water quality parameters evaluated daily (PH, Temp.salinity, Colour, transparency)
8. Chlorination kills all pathogenic microbes as well as chemically removes iron by forming a red precipitate with it (Yes/No)
9. Do you treat the effluent before discharging into the water supply? (Yes / No)
10. you know the recommended ranges of values for these? (Yes / No)
11. Whether other water quality evaluation tests done (TSS, BOD, COD, DO, TN, TP)
12. Do you record it (Yes / No)

Inspection

1. How many times a day do you carry out the walk through examination ; (7 A.M, 2 P.M, 10 P.M)
2. What are the parameters examined (tank water condition, aeration, algal density, artemia density, animal behaviour, health, feeding etc.)
3. Whether the microscopic examination is done on (swimming activity, feeding, morphological and developmental stages, symptoms of stress, presence of parasites and diseases etc.)
4. Do you encounter any quality problems in the PL raised ? (Yes / No)

Transportation

1. Is it in order to reduce the normal activity of the PL that the temp. in the tub is reduced to 50c before packing for transportation (Yes/No)
2. The water to air ratio in the transportation packets should be 1:3 (Yes/No)
3. Whether the bag is placed in a cardboard carton lined inside with thermocole sheet during transportation (Yes/No)
4. Why feed is avoided in the bag while in transportation (this will affect the water quality)
5. How is the packing density of the PLs in the bag decided upon(based on the transportation time and size of PLs.
6. Are you transporting the seeds in transportation bags? (Yes / No)
7. Do you know that there are recommended densities of seeds in transportation bags?
8. (Yes / No)
9. Do you separate the weak seeds before stocking/ (Yes / No)
10. Do you carry out the PCR test before selling the seed (Yes / No)

Drug treatments

1. Whether the bioassay is conducted in the laboratory before a new batch of drugs is applied (Yes/No)
2. Do you take care to avoid drug treatments at transition stages (Yes/No)
3. Are you using only aquatic grade drugs which are water soluble (Yes/No)
4. The drugs should be dissolved in fresh water and administered near aeration points for thorough mixing (Yes/No)
5. All prophylactic and therapeutic treatments are given immediately after water exchange and feeding (Yes/No)
6. Photodegradable drugs should be given during night time (Yes/No)

Laboratory

1. Is there a laboratory attached to the larval rearing section (Yes / No)
2. Whether the laboratory is equipped with necessary equipments for conducting microbiological studies (Yes / No)
3. Is there a PCR lab attached to the hatchery (Yes / No)

4. Do you carry out the PCR test (Yes / No)

Equipments, Chemicals and drugs

1. Whether equipments (microscope,haemocytometer, PH meter, salinometer,autoclave, air oven, incubator, seawater testing kits etc.), adequate quantity of glasswares and utensils like Strainers with 100,250,350 and 500 nylon mesh, harvesting buckets, plastic buckets, tubs, plastic cans, glass and plastic beakers, feeding trays etc. are available (Yes / No)

2. Whether bleaching powder, detergents, antibiotics(chloramphenicol, oxytetracycline, erythromycine, furazolidon, prefuran), fungicides (Treflan, Malachite green, Formaline)
   EDTA and other required chemicals are available (Yes / No)

Disease management

1. History of disease outbreaks
2. Peak disease season,if any noticed
3. Which of the following diseases are more frequent? (bacterial, fungal, protozoan and or nutritional/toxic/environmental)
4. What measures are taken for preventing cross- contamination ?
5. In case a disease outbreak occurs,
6. You discontinue the operation till the pathogen is eradicated by disinfection and drying (Yes/No)
7. Try to fight against the disease with drugs (Yes/No)
8. According to your opinion, which of the following primary stress factors affect most adversely (pollution effects, under-nourishment, overcrowding, bad water quality)

Disinfection and Shut down operations

1. Do you clean and sanitize the utensils before and after each use (Yes/No)

2. Whether the culture tanks, utensils, walls and floor of the building and reservoir are cleaned with a detergent and washed with fresh water (Yes/No)
3. What is the concentration of chlorine used for disinfection (200ppm)
4. How many days it is allowed to dry (7days)
5. Whether the PVC lines are filled with 1000ppm chlorine for three days (Yes/No)
6. Whether the water supply lines and reservoir tanks cleaned and disinfected at frequent intervals (Yes/No)
7. What is the concentration and duration of formalin soaking(50ppm for 3 days)
8. Whether rinsed with freshwater and dried (Yes/No)
9. Cleaning and drying of every part of the hatchery is essential to ensure better production in the next cycle (Yes/No)
10. Whether the facility is shut down at least annually for maintenance work (Yes/No)
11. Are you recording the day to day activities to facilitate production traceability and economic efficiency (Yes/No)

Hygiene precautions

1. Are you restricting the movement of people, equipments and other things from one section to the other (Yes/No)
2. Whether the employees are following good hygienic practices (Yes/No)
3. Whether proper washing facilities and hand and foot dips are provided at the entrance to each section (Yes/No)

General

1. Do you possess any literature on good hatchery management practices (Yes / No)
2. Do you know there are standards for hatchery feeds(Yes / No)
3. Do you know there are guidelines for influent and effluent water (Yes / No)
4. Have you undergone any training in any aspects of hatchery management (Yes / No)

5. Which agency provide you with the necessary technical support (Govt. , Private, both)
6. Have you got any financial assistance from the Govt. or Govt. agencies (MPEDA, BFFDA, ADAK)
7. Whether HACCP plan is implemented ? (Yes / No)
8. Are the CPs and CCPs clearly demarcated? (Yes / No)
9. Are there effective monitoring procedures? (Yes / No)
10. Whether corrective action techniques are satisfactory ? (Yes / No)
11. Are there proper record keeping procedures ? (Yes / No)
12. Are you satisfied with the present quality control set up ? (Yes / No)
13. What are the factors influencing quality?
    (Spawners, feed, water quality, all these)
14. Are you aware of the latest developments in the field of quality assurance in seafood in India and abroad ? (Yes / No)
15. Which aspect is more difficult (water/ feed/ disease management)
16. Do you monitor the cost components regularly? (Yes / No)
17. Are you satisfied with the present level of production output ? (Yes / No)
18. What is the peak season of demand for your product ?
19. Is the buyer and the price pre fixed? (Always, sometimes, never)
20. What is the selling price of PL
21. What are the problems faced by you in this field ?

Date Signature

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