Shrimp Culture
Economics, Market, and Trade
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Edited by

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Aquaculture is a dynamic field that is advancing at a rapid pace. It is critical for researchers, producers, businessmen, and government officials to stay abreast of current developments. The World Aquaculture Society (WAS) is organized for scientific purposes to promote educational, scientific, and technical development and advancement of world aquaculture by encouraging teaching, communication, and information dissemination. Today the society has more than 2,500 members in 85 countries who are connected with their colleagues worldwide through meetings, publications, and the Gateway to Aquaculture at www.was.org. WAS is associated with other aquaculture associations in Canada, Europe, Asia, China, Korea, South Africa, and others. In addition, the United States, Japan, Latin America, and Asian-Pacific Chapters also have been established to focus on aquaculture issues unique to their needs. WAS hosts meetings annually that include technical sessions and a large trade exposition attended by more than 2,000 participants from Europe, Asia, Africa, Australia, and the Americas. The WAS publishes the *World Aquaculture* magazine quarterly and its web portal www.was.org provides access to a wide range of aquaculture related information, books, and products.

The society has recently partnered with Blackwell publishing to produce the *Journal of the World Aquaculture Society*. The journal is one of the highest rated publications in the field containing peer reviewed scientific papers reporting the results of aquaculture research. In addition to its own special book publications, the WAS also has partnered with Blackwell to publish technical books based on special sessions organized at WAS annual meetings. These books provide an invaluable source of information to aquaculturists worldwide.
Preface

Shrimp is the most important commodity by value in the international seafood trade. Exports of shrimp and shrimp products in 2003 exceeded US$11 billion and represented 17% of the world’s total exports of seafood products. Much of this increase was fueled by the rapid expansion of shrimp farming around the world. Global farmed shrimp production grew phenomenally from 0.2 million metric tonnes (mmt) in 1985 to nearly 1.8 mmt in 2003, and in terms of value from $1.1 billion to more than $9.3 billion for the same period. Farmed shrimp production gradually increased its share to over 34% of total shrimp production in 2003.

While much has been written on the biological and technical aspects of shrimp farming, the literature on the economics of shrimp farming is quite limited; many would agree that it is an important area that needs more attention. The economics of aquaculture is still a rather new but growing academic discipline. Together with the recent rapid growth of aquaculture worldwide, economic research has been receiving more attention lately as can be seen by the increasing number of presentations at the annual World Aquaculture Society meetings as well as journal publications. As shrimp is one of the most important species cultured globally in terms of production, international trade, foreign exchange earnings, and impacts on local communities and environments, economic research on shrimp farming has recently been receiving much attention. The purpose of this volume is to bring together some of the recent works and research findings of researchers around the world working in various aspects of the economics of shrimp farming. This volume is intended primarily for shrimp researchers and extension workers particularly economists, although commercial producers, marketers, and government and nongovernment organizations could also benefit from the useful and practical information presented.

This volume is an outgrowth of papers presented at a special session in the World Aquaculture 2004 Conference in Honolulu, HI, USA. The special session on the Economics of Shrimp Farming was cosponsored by the International Association of Aquaculture Economics and Management (IAAEM) and the US Marine Shrimp Farming Consortium. There were 13 papers presented in this session. Those originally on the program but unable to attend were also invited to submit papers for this volume, along with a few more authors. The manuscripts were all refereed in a double-blind review process similar to that used for journal publications.

While this volume is not intended to be a comprehensive treatment of all aspects of the economics of shrimp farming, it does cover four major topics that include (1) market and trade, (2) economics of sustainable development, (3) economics of shrimp farming in selected regions, and (4) economics of recirculating systems, feeding, and production.
management. Part I in market and trade consists of four chapters. In Chapter 1, Audun Lem provides an overview of global shrimp production and trade, which serves as a background document on the current situation in world shrimp trade. In Chapter 2, Junning Cai and PingSun Leung present a global assessment of the export performance of frozen cultured shrimp in the three major markets of the United States, Japan, and the European Union. They use a modified revealed comparative advantage index for a systematic analysis. In Chapter 3, Audun Lem attempts to illustrate the crucial importance of the World Trade Organization (WTO) for world fish trade by outlining the most relevant WTO rules for fisheries as well as the issues in the ongoing WTO trade negotiations. He also provides an update on the recent Doha Round of multilateral trade negotiations and a special reference to the recent antidumping actions. In Chapter 4, Bith-Hong Ling examines the recent structural changes of Japan’s shrimp import trade as well as the implications of the recent changes in its import regulations. In Chapter 5, Alison M. Keefe and Curtis Jolly develop an international shrimp aquaculture technology diffusion rate model embracing a supply and demand framework to evaluate the effects of technology diffusion on producer profitability.

Part II is devoted to six chapters investigating the sustainability of shrimp farming from a socioeconomic point of view. The shrimp industry has been continuously accused of creating negative environmental externalities. In Chapter 6, Carole Engle and Diego Valderrama use enterprise budgets to evaluate the effects of several components of Best Management Practices on farm profitability and on the corresponding quantities of net nutrient discharge from semi-intensive shrimp farms in Honduras and cooperatives in Nicaragua. In Chapter 7, Francisco Martinez-Cordero and PingSun Leung discuss the usefulness of modified productivity and efficiency analyses that take into account environmental externalities as tools for aquaculture policy and decision making at government and firm levels, and the benefits of evaluating them on a periodic basis. They argue that these new indicators allow for a better assessment of aquacultural activities by evaluating enterprises not only for obtaining the target product but also for how successfully farms minimize the volume of undesirable wastes and pollutants. In Chapter 8, Pascal Raux, Denis Bailly, and Tran Van Nhuong make the case that many threats hang over the Vietnamese shrimp industry in spite of statistics that appear encouraging in terms of volume and value. The potential problems derived from negative effects relate to added value and local impacts. Although progress has been made recently to refine relationships between deltaic ecosystems and shrimp farming, the chapter indicates that more remains to be done, especially at the ecosystem and global levels through participative and integrated approaches. In Chapter 9, Donna Brennan, Helena Clayton, Nigel Preston, and Tran Thanh Be provide an analysis of the long-term social and private benefits of alternative shrimp recruitment practices in the Mekong Delta, and some of the policy challenges associated with encouraging the adoption of less degrading practices. In Chapter 10, Ruangrai Tokrisna uses a logit model to investigate the decision leading to and the earnings from shrimp farming among different land types on the east and west coasts of southern Thailand. In Chapter 11, Brian Szuster provides a review of shrimp farming in Thailand’s central plains region and a discussion of the environmental implications of this activity on critical soil and water resources.

Part III provides an overview of the economics of shrimp farming in several selected regions and countries primarily in Asia where most of the world’s farmed shrimp are produced. Readers are referred to a recent special issue of Aquaculture Economics and Management (Volume 8, Issues 3 and 4, 2004) for a compilation of economic analyses
of shrimp farming in Latin America. In Chapter 12, Lawrence Lai, Ken K.H. Lam, F.T. Lorne, and S.K. Wong document the history and evolution of the culture of shrimp in “gei wais” developed in mangrove swamps in the marshes, with a focus on the economics of the environment and the marketing of the product “gei wai shrimp” in competition with captured marine shrimp in Hong Kong. In Chapter 13, David S. Liao and I-Chiu Liao assess the economic aspects of the shrimp industry in Taiwan in the past decades and identify several major factors affecting the economic performance and sustainability of shrimp farming using production function analysis. In Chapter 14, Yongming Yuan, Junning Cai, and PingSun Leung provide an overview of the history and current status of both marine and freshwater shrimp farming in China, as well as the domestic and export markets for China’s shrimp products. They also provide a discussion on lessons learned from the development of China’s cultured shrimp industry and their emerging challenges. In Chapter 15, Wilfredo Yap and Antonio C. Villaluz present an economic analysis of shrimp farming in the Philippines based on a sample of 40 farms. They also identify the common characteristics of the successful farms. In Chapter 16, Madan M. Dey, Roslina Kamaruddin, Ferdinand J. Paraguas, and Ramachandra Bhatta discuss the status of shrimp farming, and evaluate the level of profitability, the relative competitiveness in the production and trade of shrimp, and the technical efficiency in the major shrimp-producing countries of Bangladesh, China, India, Indonesia, the Philippines, Sri Lanka, Thailand, and Vietnam. While much of the attention has been focused on marine shrimp, the significant growth of freshwater prawn in the recent decade has also been a focal point in this rather large shrimp and prawn industry complex. In Chapter 17, Wagner Valenti and James H. Tidwell describe the productive chain, production strategies, and costs as well as selling prices and economic indicators of freshwater prawn culture in the western hemisphere. They show that freshwater prawn farming can be a feasible and profitable business in the western hemisphere. It is becoming a solid and sustainable activity which may be an important means of promoting social and economic development in many areas, and doing so with very little environmental impact.

The last part consists of four chapters covering the economic evaluations of the recently developed recirculating systems, the economics of feeds and feeding, and the production management of a shrimp-farming complex. Biosecure indoor recirculating marine shrimp production systems have been proposed as the next revolution in shrimp farming. These systems require significantly less water per crop, thereby minimizing the potential for pathogen introduction into the shrimp culture environment. In addition, nutrient and biological pollution of the natural environment are minimized or eliminated. In addition, they can be used to produce shrimp at inland locations that are in close proximity to markets and away from sensitive coastal areas where multiple-use conflicts exist. Because of these advantages, interest in the use of recirculating systems for shrimp culture has increased, especially in those countries where land costs are expensive and environmental regulations are strict. In Chapter 18, Benedict Posadas and Terrill Hanson use an extended version of their bioeconomic simulation model to assess the profitability of incorporating the nursery component into a hypothetical biosecure indoor recirculating shrimp production system. In Chapter 19, Shaun Moss and PingSun Leung compare production costs of shrimp reared in coastal, earthen ponds versus a hypothetical biosecure recirculating system using shrimp performance data from research results at the Oceanic Institute. In Chapter 20, Albert G.J. Tacon, Sergio F. Nates, and Roderick J. Mcneil present an overview of the different farming systems and
feeding strategies employed by farmers, including estimated shrimp production costs. In addition, they present information concerning global shrimp feed production, the contribution of feeds and feeding to shrimp production costs, and guidelines concerning on-farm feed use and management. In Chapter 21, Run Yu, PingSun Leung, and Paul Bienfang present an ongoing effort in developing a practical decision support system to assist shrimp producers to optimally schedule their stocking and harvesting events in a way that maximizes profitability in a multipond and multicycle commercial setting.

Finally, we thank the authors of this volume for their contribution and their patience and endurance throughout the preparation of this volume. Thanks are also due to the reviewers. Each of the chapters has been reviewed by two referees. The reviewers are Denis Bailly, Donna Brennan, Junning Cai, Madan Dey, Carole Engle, Terrill Hanson, Alison Keefe, Lawrence Lai, Ed Leano, Audun Lem, David Liao, I-Chiu Liao, Bith-Hong Ling, Shaun Moss, Francisco Martinez-Cordero, James Muir, Ben Posadas, Pascal Raux, Brian Szuster, Albert Tacon, Ruangrai Tokrisna, Granvil Treece, Wagner Valenti, Fred Yap, and Yongming Yuan.

We are also very grateful to Nigel Balmforth of Blackwell Publishing and Anthony Ostrowski of the US Marine Shrimp Farming Consortium for initiating this project. Appreciation is also due to Justin Jeffryes of Blackwell Publishing for his patience and continuous support during the last phase of this project. Finally, the graphic assistance provided by Kathy Lu and Bo Huang of the Publication and Information Office, College of Tropical Agriculture and Human Resources at the University of Hawaii is greatly appreciated.

PingSun Leung
Carole Engle
Part I
Market and Trade
Chapter 1

An Overview of Global Shrimp Markets and Trade¹

Audun Lem

Abstract

The chapter presents an overview of shrimp production and trade. It does not provide a detailed analysis of individual supplying countries or markets but aims to serve as a background document on the current situation in world shrimp trade.

Keywords: World, shrimp, market, trade

Introduction

Shrimp² is by far the most important commodity by value in the international fish trade. Yearly exports of shrimp and shrimp products now exceed more than $10 billion (2003) and represent almost 20% of world total exports of fish and fishery products.³ Shrimp is supplied from wild fisheries in the Northern and Southern hemispheres as well as from aquaculture. Shrimp ranks regularly among consumers’ favorite seafood and is consumed in all parts of the world, with the largest markets being the United States, Japan, and the European Union (EU).

Output from shrimp aquaculture has more than doubled over the last few decades, and a growing share of internationally traded shrimp is now coming from aquaculture. Shrimp aquaculture has an important impact on supply and demand patterns in all markets, but large supply swings caused by disease outbreaks may also have made shrimp markets more unstable.

In the following we will take a closer look at the situation in the world’s shrimp markets and some of the factors that influence demand and supply.

¹ The view expressed herein are those of the author and do not necessarily reflect the views of the Food and Agriculture Organization of the United Nations.
² Shrimp is here meant to include all types of shrimp and prawns.
³ FAO, COFI-FT/IX/2004/2, Status and important recent events concerning international trade in fishery products.
Table 1.1 Total world supply of shrimp by source (in 1000 tons), 1988 and 1996–2004

<table>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Wild</td>
<td>1,988</td>
<td>77%</td>
<td>2,564</td>
<td>73%</td>
<td>2,638</td>
<td>73%</td>
<td>2,738</td>
<td>73%</td>
<td>3,099</td>
<td>66%</td>
</tr>
<tr>
<td>Farmed</td>
<td>576</td>
<td>23%</td>
<td>917</td>
<td>27%</td>
<td>932</td>
<td>27%</td>
<td>1,068</td>
<td>27%</td>
<td>1,346</td>
<td>34%</td>
</tr>
<tr>
<td>Total</td>
<td>2,565</td>
<td>100%</td>
<td>3,482</td>
<td>100%</td>
<td>3,571</td>
<td>100%</td>
<td>4,099</td>
<td>100%</td>
<td>4,468</td>
<td>100%</td>
</tr>
</tbody>
</table>

Source: FAO FISHSTAT.

Supply

It is well known that shrimp today comes from both capture fisheries and aquaculture. However, as species, shrimp can be divided into two large subcategories, cold-water and warm-water shrimp, of which the first is wild caught and the second may be either wild caught or farmed.

Cold-water shrimp comes from capture fisheries in the Northern hemisphere, and the shrimp is generally small in size. It is not farmed. The most important cold-water species in 2004 are the Northern prawn or pink shrimp (*Pandalus borealis*) (446,000 tons), Northern white shrimp (57,000 tons), and Common shrimp (*Crangon crangon*) (39,000 tons). The principal capture countries for cold-water shrimp are Greenland, Canada, Iceland, Norway, and the United States.

Warm-water shrimp comes from both capture fisheries and aquaculture. The large increase in aquaculture of warm-water species has increased total supply of warm-water shrimp significantly over the last 30 years. The most important species are black tiger or giant tiger prawn (*Penaeus monodon*) and white shrimp (*Penaeus vannamei*). White shrimp in particular has shown strong growth in recent years.

Of total shrimp aquaculture production of 2.5 million tons in 2004, 722,000 tons were black tiger (*P. monodon*) and 1,386,000 tons white shrimp (*P. vannamei*). Thailand, Vietnam, Indonesia, and India are the main producers of farmed tigers; China, Thailand, Brazil, Ecuador, Mexico, and Vietnam of white shrimp. Especially Asian countries such as China and Vietnam have increased their farmed shrimp production in recent years, but also Brazil has boosted its output significantly.

Whereas data on the respective sources of supply (capture or aquaculture) are fairly reliable (Table 1.1), the information about the origin of shrimp entering international trade is less clear. The main reason for this is that trade statistics do not indicate the production method (wild or farmed) used for the respective species. In any case, we do know that most farmed shrimp is intended for exports, some estimate as much as 80% (Anderson et al. 2003). By this measure, 60% of the total value of international shrimp trade now comes from aquaculture. One can therefore safely conclude that the share of aquaculture in international shrimp trade has increased in both absolute and relative numbers.

Major suppliers

The major producers (capture + aquaculture) of shrimp in the world today (2004) are found in Asia, followed at some distance by the United States, Canada, and Mexico (Table 1.2).
When looking at aquaculture in particular (included in Table 1.2), all the major producers are situated in Asia and in Central and South America (2004) (Table 1.3).

The major exporting countries in the world are shown in Table 1.4.

With so much of shrimp production and exports originating in developing countries, it is clear that the shrimp industry is of particular economic importance to this group of countries, not only in terms of overall employment and rural job creation but also as a generator of foreign exchange earnings. The shrimp processing industry with its thousands of workers employed in the peeling operations is also mainly dependent upon female labor and therefore provides important jobs for women who frequently may have few other employment opportunities.

Whereas shrimp fisheries and aquaculture production have clearly brought benefits both to fishermen and farmers, to processors and traders, as well to distributors and consumers, it is also a fact that there have been problems, both linked to the sustainability of wild shrimp resources and of practises used by some operators in aquaculture production. For example,
## Table 1.4 World shrimp exports by country in 2003

<table>
<thead>
<tr>
<th>Exporters</th>
<th>Thousand tons</th>
<th>Value (million dollars)</th>
<th>% Quantity</th>
<th>% Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thailand</td>
<td>234</td>
<td>1,732</td>
<td>13</td>
<td>16</td>
</tr>
<tr>
<td>Vietnam</td>
<td>125</td>
<td>1,058</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>India</td>
<td>175</td>
<td>897</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>China</td>
<td>189</td>
<td>882</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>Indonesia</td>
<td>123</td>
<td>789</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Denmark</td>
<td>109</td>
<td>432</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Argentina</td>
<td>47</td>
<td>383</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Canada</td>
<td>78</td>
<td>345</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Netherlands</td>
<td>39</td>
<td>341</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Ecuador</td>
<td>53</td>
<td>276</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Greenland</td>
<td>98</td>
<td>229</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Malaysia</td>
<td>29</td>
<td>123</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Others</td>
<td>543</td>
<td>3,462</td>
<td>29</td>
<td>32</td>
</tr>
<tr>
<td>Total</td>
<td>1842</td>
<td>10,949</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: FAO FISHSTAT.

shrimp aquaculture has, in some countries, been accused of environmental degradation of mangroves and of displacement of farmers. Whereas this in some instances undoubtedly has been the case, in particular in the 1980s and early 1990s as the industry was expanding and gaining experience, it would be wrong to apply this characterization on a general basis. Most shrimp operations today can be categorized as operating according to environmentally sound principles and within laws and regulations set down by national authorities.

Another aspect frequently raised in connection with aquaculture production of shrimp and which has a large impact on supplies from individual countries is that of quality and safety in general, and of residues from antibiotics in particular. Food quality and safety measures in importing countries today are, along with import tariffs, the most important barrier to trade, and the evermore stringent import requirements to food and fish products have placed a large regularity burden upon producers and exporters in developing countries. However, the 50% share of developing countries in international fish trade as well as their dominant role in shrimp production and exports show that these barriers are not insurmountable and that developing countries have an important place both in production and exports and increasingly also as markets.

### Demand and markets

Despite growing output, shrimp and shrimp products are still generally considered high-value species or luxury products with high appeal among consumers and strong demand also from the catering or restaurant sector. In fact, with increasing production and trade, availability has also increased and restaurants all over the world are today able to offer shrimp as part of their regular menu. However, with shrimp prices often showing large fluctuations this means that changes in the shrimp price soon translate into price changes on the menu or on the supermarket shelf.
In general, demand for shrimp is considered to be quite price elastic in the sense that a change in the price of shrimp has strong effects also on the demand for shrimp. Studies undertaken on elasticities for shrimp confirm this. This fits with the usual observation that high-valued species tend to have a more elastic demand (Asche and Bjørndal 2000).

At the same time, because of the fragmented structure of international shrimp trade, it is difficult to find any single price quote that can be representative for more than a small part of traded shrimp products. It is also difficult to construct any price index that is representative for traded shrimp products in general. Not only do shrimp products belong to separate markets depending on demand characteristics (Fig. 1.1 and 1.2), their relative relationship...