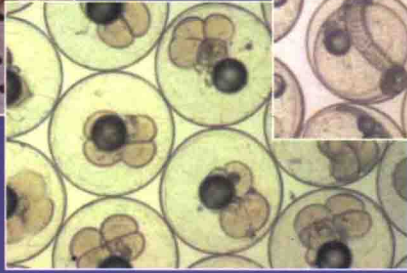
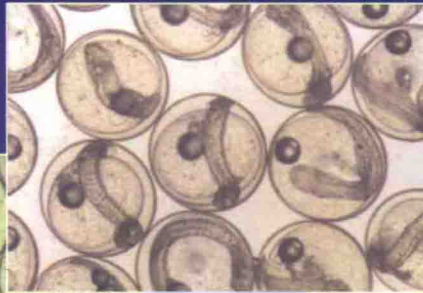


# COBIA AQUACULTURE:

## Research, Development and Commercial Production

*Edited by: I Chiu Liao and Eduardo M. Leaño*



# **Cobia Aquaculture: Research, Development and Commercial Production**



*Edited by*

**I Chiu Liao  
and  
Eduardo M. Leaño**

*Department of Aquaculture  
National Taiwan Ocean University  
Keelung, Taiwan*

**February 2007**



**WORLD  
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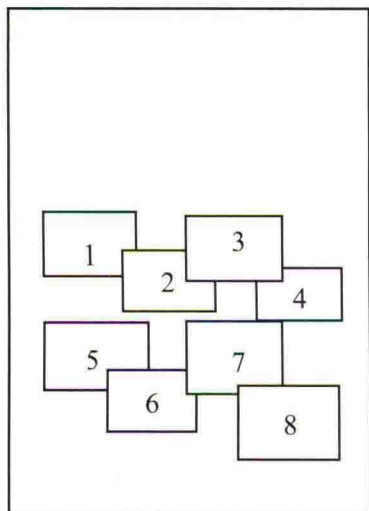
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## Preface

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It is a great pleasure to congratulate the Center for Marine Bioscience and Biotechnology of the National Taiwan Ocean University (NTOU) and the Fisheries Society of Taiwan, for taking the initiative and funding to produce this latest publication on “Cobia Aquaculture: Research, Development and Commercial Production”, edited by Drs. I Chiu Liao and Eduardo M. Leaña. And on behalf of the Asian Fisheries Society, as one of the co-publishers of this book, I would like to extend our appreciation to the World Aquaculture Society for the support and cooperation.

Cobia, *Rachycentron canadum*, aquaculture attracted my attention during the 1<sup>st</sup> International Symposium on Cage Aquaculture in Asia held in Kaohsiung, Taiwan in 1999. I was very impressed by the preliminary R&D work conducted on this species by Taiwanese researchers, and the potential of cobia for aquaculture in the Asia-Pacific.

After its initial success, cobia aquaculture has made considerable progress in the past six years, and is developing rapidly in many parts of the world, especially in the Asia-Pacific. Specific sessions have been held on cobia culture during the World Aquaculture Society (WAS) meetings in Hawaii (2004), Bali (2005) and Florence (2006). These activities have collectively expanded information on the husbandry of the species and enhanced the commercialization of cobia in Asia.

This book presents a first global review of cobia aquaculture practices based on work conducted in Taiwan, Indonesia, Japan, France, the Americas and the Caribbean. It also contains chapters on larval rearing, nursery production and juvenile nutrition of cobia. This publication “Cobia Aquaculture: Research, Development and Commercial Production” is therefore timely and fills a much needed gap in providing the latest information and a summary on the state of aquaculture of this species.

I have no hesitation in recommending this book for fisheries libraries and as a ‘must read’ volume for all researchers and commercial producers involved in cage aquaculture.

From the Asian Fisheries Society and its governing Council, I would like to congratulate and thank Fisheries Society of Taiwan and NTOU for leading this joint publication on cobia. I believe that it will be a highly successful publication.

*Chan-Lui Lee*  
President  
Asian Fisheries Society



# Preface

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On behalf of the World Aquaculture Society, it is my pleasure to support this important reference work. While aquaculture continues to grow at a brisk pace (averaging 8.8% growth per year since 1950), capture fisheries' "production" has remained relatively flat. The ever increasing demand for seafood seems to guarantee continued aquaculture growth, and we are poised for even more advancement. The advancements that I foresee will be both technological and biological.

Technologically, we are experiencing rapid new developments and innovations in sea cage designs and related technologies which will allow for expansion of sea cage culture into high-energy, open ocean environments. Other technological developments include improved recirculating systems (for broodstock spawning and larval-rearing), better feed delivery efficiency, water quality monitoring, and surveillance/supervision systems. These advances will open the way to the production of more high-quality seafood (including new culture species) at reduced costs. This offers our industry the opportunity to increase seafood's market share in overall protein consumption, particularly in luxury markets of developed countries.

One of the biological advancements we are experiencing is the development of new culture species, and Cobia is an excellent example of this. Research in cobia production began relatively recently (only about 10 years ago) and yet here we are publishing a book that not only highlights this research from around the globe but details the associated commercial development of this species. This book truly illustrates how swiftly our science is progressing and building upon itself. Scientists from Asia, the United States, and Europe are conducting research on improving broodstock management, hatchery techniques, larval rearing and grow-out methods, and increasing the understanding of the nutritional requirements of cobia.

Whether you are an aquaculture professional, a producer, or simply a seafood consumer, you have to be excited about where we've been, where we are today, and most importantly where we are going with our science and industry in the future. This book on Cobia is an example of the continued maturation of our science and the industry that develops around it. It is through publications such as this that we can develop truly sustainable and environmentally-sound aquaculture.

*Michael P. Masser*  
*President (2006-2007)*  
*World Aquaculture Society*



## Preface

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This book project was initiated in September 2005 after realizing the significantly growing importance of cobia, as newly introduced species, in the aquaculture industry all over the world. As the current President of The Fisheries Society of Taiwan, I took the opportunity to make this as a major project of the Society which has been supporting information dissemination in the fields of aquaculture and fisheries since it was established in 1955. The Society has been actively promoting the industry not only locally by hosting annual meetings, but also internationally by supporting some of the activities of international organizations (e.g. Asian Fisheries Society). Moreover, the Society has been publishing its in-house journal, *Journal of the Fisheries Society of Taiwan*, which is also recognized internationally. The journal contains scientific contributions from its members and their collaborators.

This project, however, will not become a reality without the full support of the National Taiwan Ocean University (NTOU), especially the Center for Marine Bioscience and Biotechnology which provided the funding. The Center was established in August 2006 with financial support from the Ministry of Education, Taiwan. It encourages the integrative and cooperative research and academic activities university-wide, as well as in the national and international levels. The main goal of the Center is to develop and promote research areas in marine and fishery sciences, including aquatic life science. On the applied aspect, the Center focuses on development of key technology, teaching and education, technology transfer and information dissemination. Thus, this book on cobia is a relevant project of the Center for information dissemination of recent worldwide developments in cobia aquaculture.

I would like take this opportunity to thank all the contributors for this book, for their great work on cobia research and development, commercial production, as well as other aspects of its culture including post-harvest and fish processing. I am sure that the information that you shared will be of great use not only for aquaculture scientists, but also for students, and private sectors who are interested to put-up their own cobia rearing facilities. Appreciation also goes to the co-publishers of this book, the Asian Fisheries Society and the World Aquaculture Society, for their cooperation and support. Lastly, I would like to extend my thanks to some of my staff and colleagues who assisted us in some minor details of this book, including Dr. Nai-Hsien Chao, Mr. Ming-Yao Lin, Ms. Chia-Chen Yu, Mr. Wann-Tseng Tsai, Dr. Jhy-Yun Shy, Dr. Su-Lean Chang, Dr. Jinn-Pyng Ueng, Dr. Ming-Shiou Jeng, Mr. Chen-Yu Hsu, Dr. Hung-His Hu and Mr. Sunny Wang.

*I Chiu Liao*

*President*

*The Fisheries Society of Taiwan*

## Preface

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It is a great honor for the National Taiwan Ocean University (NTOU) to co-publish this very important and timely book on cobia aquaculture. NTOU is one of the leading Universities for fisheries and aquaculture-related studies in Taiwan. In fact, three of our six colleges (Maritime Science and Management, Life Sciences, and Ocean Science and Resource) incorporate in their curriculum fisheries and aquaculture research and studies towards efficient management and utilization of our marine resources. Since its establishment in 1953, the University has undergone great growth and significant changes, that it is now recognized as one of the nation's most important centers for learning and scholarships, especially in the marine sciences and maritime studies.

Cobia is presently considered as one of the most popular aquaculture species in Taiwan, especially for off-shore marine cage culture. I believe that the information contained in this book will benefit not only the researchers and academicians, but the private sectors as well. I would like to take this opportunity to thank the editors of this book, Chair Professor I Chiu Liao and Dr. Eduardo M. Leaña, both from the Department of Aquaculture of this University, for making this book project a reality, and the funding support from The Center for Marine Bioscience and Biotechnology, also of NTOU. I would also like to thank all the chapter contributors for their great efforts in undertaking relevant researches and projects for the development of cobia aquaculture worldwide, and for those involved in commercial production of this species. Lastly, I thank the Asian Fisheries Society, the World Aquaculture Society, and the Fisheries Society of Taiwan for co-publishing this book.

*Kuo-Tien Lee*

*President*

*National Taiwan Ocean University*

# Introduction

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The aquaculture of cobia (*Rachycentron canadum*) has gained momentum worldwide, after its successful commercial production in Taiwan. Previously considered as an important recreational species (Chen 1986; Ditty and Shaw 1992), its potential for culture was recognized in Taiwan in the early 1990s. Fast growth rate, adaptability for captive breeding, lower cost of production, good meat quality and high market demand especially for the sashimi industry, are just some of the attributes of this species that makes it an excellent aquaculture species (Liao 2003; Liao *et al.* 2004). The mass propagation techniques for larval and juvenile production were easily established by researchers from Taiwan (Chang *et al.* 1997), while off-shore cage culture for commercial production immediately followed.

At present, research efforts are being undertaken in other parts of the world to refine and improve larval, juvenile and off-shore cage culture productions. The importance of cobia as a newly introduced aquaculture species has been recognized in many international meetings. In the annual meetings of the World Aquaculture Society, a separate session on cobia was organized since 2003 in Salvador, Brazil. Since then, Cobia Session is one of the most attended sessions during the succeeding WAS meetings in Hawaii, USA (2004), Bali, Indonesia (2005) and Florence, Italy (2006). It has attracted many scientists, academicians, as well as private sectors from many countries around the world, which clearly indicates the growing interests for this new species.

Thus in mid-2005, we have decided to initiate this book project by inviting well-known scientists and entrepreneurs who are involved in cobia research, development, culture and commercial production. Although some of our invited contributors either did not reply to our invitation or failed to submit their manuscripts, we have gathered a handful of manuscripts to complete this book. The first four chapters describe the very active research activities in different parts of the United States and the Caribbean. Most of the studies are focused on broodstock management and mass production of larvae and juveniles. Others include physiological studies on different environmental factors affecting growth and survival, and nutritional studies. Grow-out trials were also carried out, especially in the Caribbean region, where promising results are obtained.

The nursery rearing of cobia in Taiwan is presented in Chapter 5, where problems, recent developments and some strategies for better juvenile production are discussed. Research on nutrition and nutritional requirements of juvenile cobia, as well as feed development are then presented in Chapter 6. In Chapter 7, commercial production of cobia in Japan through cage culture is introduced, as well as their research efforts for the mass larval production. Broodstock management, hatchery and nursery culture have been initiated in Indonesia, results of which are presented in Chapter 8. Initial effort on cobia aquaculture in La Reunion Island, France is summarized in Chapter 9, which include grow-out trials in off-shore cages, broodstock



management, as well as larval and juvenile production. Taiwan is still considered having the most established technology in all aspects of cobia aquaculture. Thus in Chapter 10, commercial production of cobia in off-shore marine cages is discussed, including problems encountered during culture operations, marketing, and future outlooks in maintaining sustainable and responsible production. Lastly, meat quality and post-harvest processing for cobia are presented in Chapter 11, while economic analysis on the impact of yield insurance on cobia production in Taiwan is presented in Chapter 12.

Overall, each chapter in this book has its own story to tell, based on the actual experiences of the research team or company involved. It is assured that this book will provide a great deal of information in all aspects of cobia aquaculture and utilization, which will be useful for individuals interested in research or those interested in putting up small- or commercial-scale culture operations. As an added spice, a list of wonderful cobia recipes is added in the Appendix, where consumers will be guided on the proper way to prepare delicious cobia dishes.

*I Chiu Liao and Eduardo M. Leaña*  
Editors

## References

- Chang, S.L. C.S. Hsieh, Z.L. Chao and M.S. Su. 1999. Notes on artificial propagation and grow-out techniques of cobia (*Rachycentron canadum*). Fish World Magazine, 270: 14-26 (in Chinese).
- Chen, J.T.F. 1986. A Synopsis of Vertebrates in Taiwan. Vol. II, The Commercial Press, Taiwan. 506 pp.
- Ditty, J.G. and R.F. Shaw. 1992. Larval development, distribution, and ecology of cobia, *Rachycentron canadum* (Family: Rachycentridae) in the northern Gulf of Mexico. Fisheries Bulletin, 90:668-677.
- Liao, I C. 2003. Candidate species for open ocean aquaculture: the successful case of cobia, *Rachycentron canadum*, in Taiwan. In Open Ocean Aquaculture: From Research to Commercial Reality, C.J. Bridger and B.A. Costa-Pierce (editors). World Aquaculture Society, Baton Rouge, Louisiana, USA. p. 205-213.
- Liao, I C., T.S. Huang, W.S. Tsai, C.M. Hsueh, S.L. Chang and E.M. Leaña. 2004. Cobia culture in Taiwan: current status and problems. Aquaculture, 237: 155-165.

# Cobia Culture Operations

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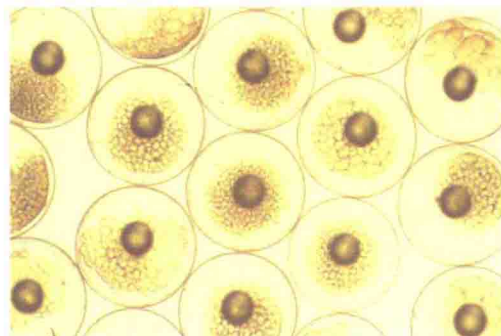
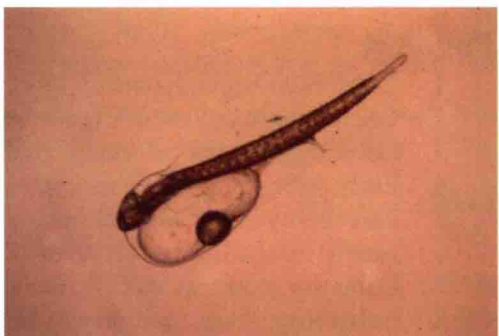
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